Agent Based Simulator

User's Manual

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Index and Infomation

Introduction

1. What Is an Agent Based Simulator?

An active entity that pursues its own benefit based on its own plan of action and decision-making mechanism associated with individual internal attributes is termed an "agent", and the term "multi-agent" is used to refer to an aggregate of correlated agents.

As an example, in a simulation of how stock prices are determined, the persons who wish to buy and sell stocks are called agents. In this case, individual examination of the buyers and sellers (agents) does not reveal the whole picture. This is because stock prices are determined according to supply and demand (the mutual relationships between sellers and buyers) by invisible mechanisms acting within the group that differ from the rules of the individual active entities (agents).

In this way, *Agent Based Simulator* (ABS) simulates systems (complex systems) in which the rules for the behavior of the elements that make up the system change dynamically according to the overall context.

2. Operating Environment

A personal computer running Windows 95/98, Windows NT 4.0, or Windows 2000

3. Installing and Uninstalling

Installation and Setup

1. ***Run abs.exe to create a folder called disk1.***
2. ***In the disk1 folder, run Setup.exe.***

Uninstalling

1. ***In Control Panel, double-click Add / Remove Programs.***
2. ***At the Install / Uninstall tab, select Agent Based Simulator from the list of programs, then click Uninstall.***

4. Basic Concepts

Agent

The dictionary defines agent as "one who acts (on behalf of another)", but here it is a construct that is substituted for an actual entity in a simulation and behaves as if it were that entity. It exerts effects on itself and others according to certain rules. In specific terms, an agent performs actions such as referencing and changing the values of its variables, creating new agents, and deleting old ones. To speak figuratively, it can see items that other people are carrying (variables), and can give and receive such items, but it doesn't know what other people are thinking (rules).

World agent

This is a special agent at the highest level and forms the frame of reference for this simulation. Other components are defined within it, producing the simulation model.

Space

This is a two-dimensional space to which an agent or variable belongs.

Variable

This is like a carton for string and numerical value, text, or other data that an agent has. It corresponds to terms such as *x* and *y* in mathematics. Computers cannot process vague definitions such as "friendly" or "short-tempered", and so all aspects of an agent's "personality" are maintained as numerical and text data in these variables.

Local variable

This refers to a variable used temporarily only within an agent rule. Other agents do not have access to it.

Agent rule

This is a rule that governs how an agent acts. In a simulation, an agent acts according to such rules. The values of variables may change, but agent rules remain unchanged unless modified by the user. There are three kinds of agent rules; initial rules (Agt_Init) which are executed once when an agent is created, execution rules (Agt_Step) which are executed at each step through a simulation, and user-defined functions which are defined by the user.

Model

This refers to the set of components that the user constructs. The state when components have been placed, rules have been formulated, and settings for output and the like have been completed is called the model.

ABS file

This is a file in which the data for a created model is saved. It is made up of component information and information on simulation settings, and if a log has been made, it also includes the log data.

5. How This Manual Is Organized

This manual is made up of three chapters, an appendix, and an index.
The contents of each are as follows.

Chapter 1　An Introduction to Agent Based Simulator

This chapter is arranged in two parts that take a staged approach to learning. The introductory section describes how to perform actual simulations using two tutorial files, and the main text gradually builds on the knowledge acquired to create models. Start with this chapter to actually use *Agent Based Simulator* and familiarize yourself with the flow of simulations.

Chapter 2　Reference

This chapter is organized by function, and describes all of the setting screens where the user can make various settings. Use this chapter as a reference, using the index and table of contents to locate the information you need.

Chapter 3　Agent Rule Syntax

This chapter describes the syntax of the agent rules that define agents. Use this chapter as a

reference, using the index and table of contents to locate the information you need.

Appendix

This is an advanced course in *Agent Based Simulator* that will take you beyond the introductory material in chapter 1. It deepens your understanding of *Agent Based Simulator* through a hands-on approach that covers the segregation model, the forest-fire model, and other topics.

Index

This is an index to frequently used terms in *Agent Based Simulator*. The format "chapter number – page number" is used to indicate the locations where entries appear in the text.

6. Typographical Conventions Used in This Manual

The typography of this manual follows the conventions described below.

Usage of Italic type

Italic type (sometimes Bold italic type) is used to explain step-by-step procedures. Italic and normal type are used to differentiate between descriptions of procedures, and its results and supplementary explanations. For example,

1. Select Agent Based Simulator. > Description of procedure

Agent Based Simulator starts. > Operation result

Explanations after "*Important* : "

This provides additional explanations or special attentions.
This manual also assumes a basic understanding of the operations and terms of Windows. If you are unfamiliar with how to use Windows, refer to the documentation that comes with Windows.

Chapter 1

An Introduction to Agent Based Simulator

1.1 Running the Samples

Agent Based Simulator (ABS) includes two types of sample simulations that enable you to see for yourself how the program works. You can start a simulation right away simply by opening the corresponding job file (*.abs) and making a minimum of settings.
Now you're ready to start learning how to use this multi-agent simulator as you try it out for yourself.

Getting Ready

To start a simulation, the first thing you need to do is to start the multi-agent simulator and select the job file for the corresponding model.

From the Start menu, choose Programs, go to Agent Based Simulator, then to Tutorial, and select either Sugarscape Model or Segregation Model. This automatically starts Agent Based Simulator.

1.1.1 Segregation Model

A Simulation of Segregated Living Among Turtles

(1) About This Simulation

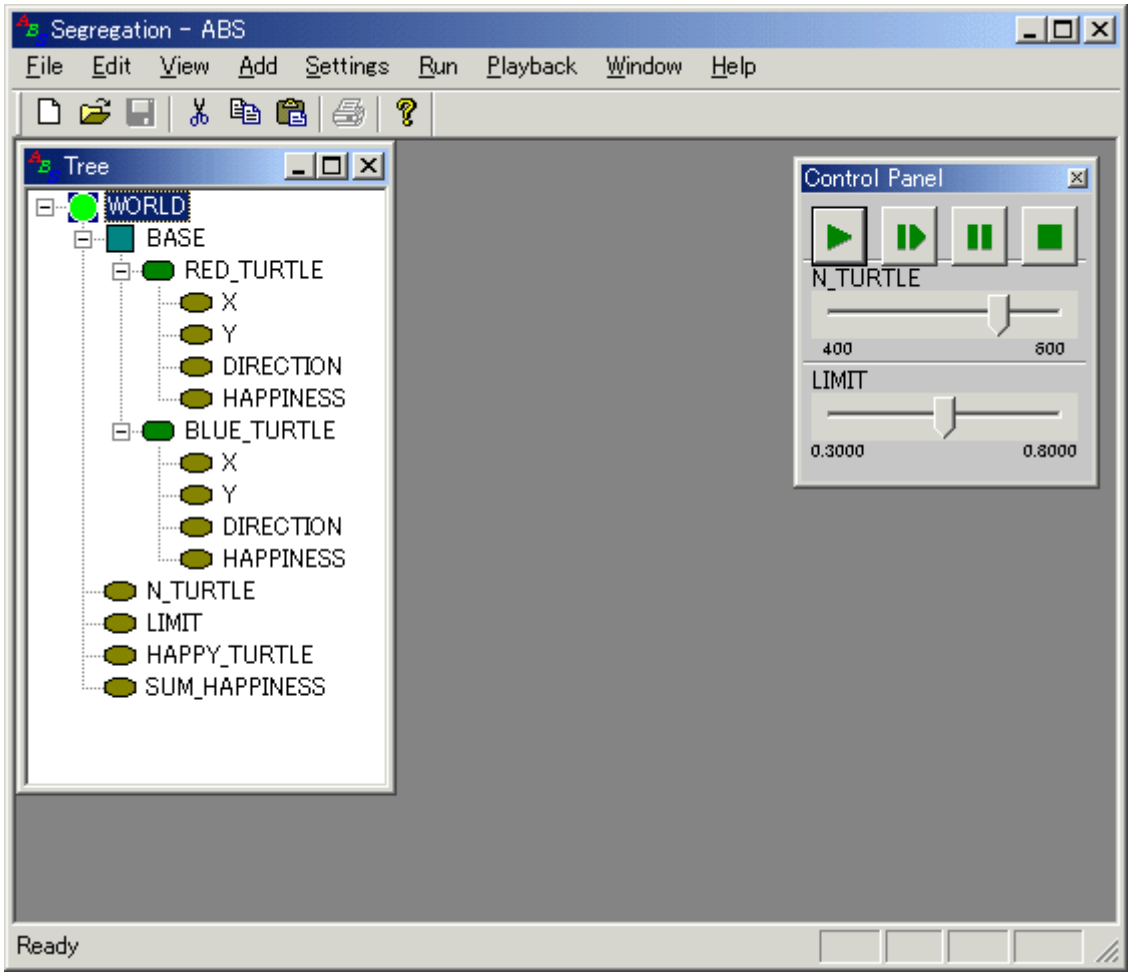
This is a model that simulates the process by which two types (red and blue) of turtles move according to certain rules, resulting in segregated living. There are no differences in the personalities or other traits of the two types of turtles.
When a turtle is surrounded by certain number of other turtles, it moves to an unoccupied space to seek more comfortable surroundings. This is the only rule established for the turtles, but it results in segregated living among all the turtles.
Of course, you can change these settings any way you like, but first, try running it with the original settings.

(2) Settings

Going into the Tutorial folder and opening the Segregation.abs file makes a window like the one in the following figure appear.

Tree

This is the most basic screen for this simulator. It displays the hierarchical structure of the



various components. One agent, the World agent, always exists in the tree. Other components such as two-dimensional space, agents, and variables exist under it. These are explained in later chapters.

For now, just think of it as something like Explorer in Windows.

Now let's try actually running it. To run it, use the floating Control Panel shown below.

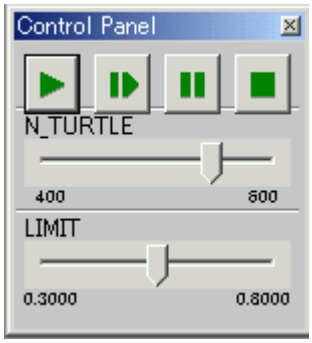
Control Panel

This window is used to control starting and stopping for simulations.

The topmost buttons, from left to right, are Run, Step, Pause and Stop.

Click Run to start a simulation, Stop to end it, or Pause to stop it temporarily.

Clicking the Step button executes a simulation one step at a time. Each click of the button executes one step, after while the simulation pause.



You can use the two sliders below the buttons to change settings in real time.

Number of Turtles varies the number of turtles shown on the screen from 400 to 600.

Threshold indicates the personality of the turtles. Moving it farther to the right makes the turtles increasingly discriminating.

Let's give it a try. In the Control Panel window, click the Run button. Did a screen like the one shown below appear?

(3) Results

You see three windows appear; Happy Turtles, Parameters, and Two-dimensional Space. The simulation continues and these windows show the results in real time until you Stop or

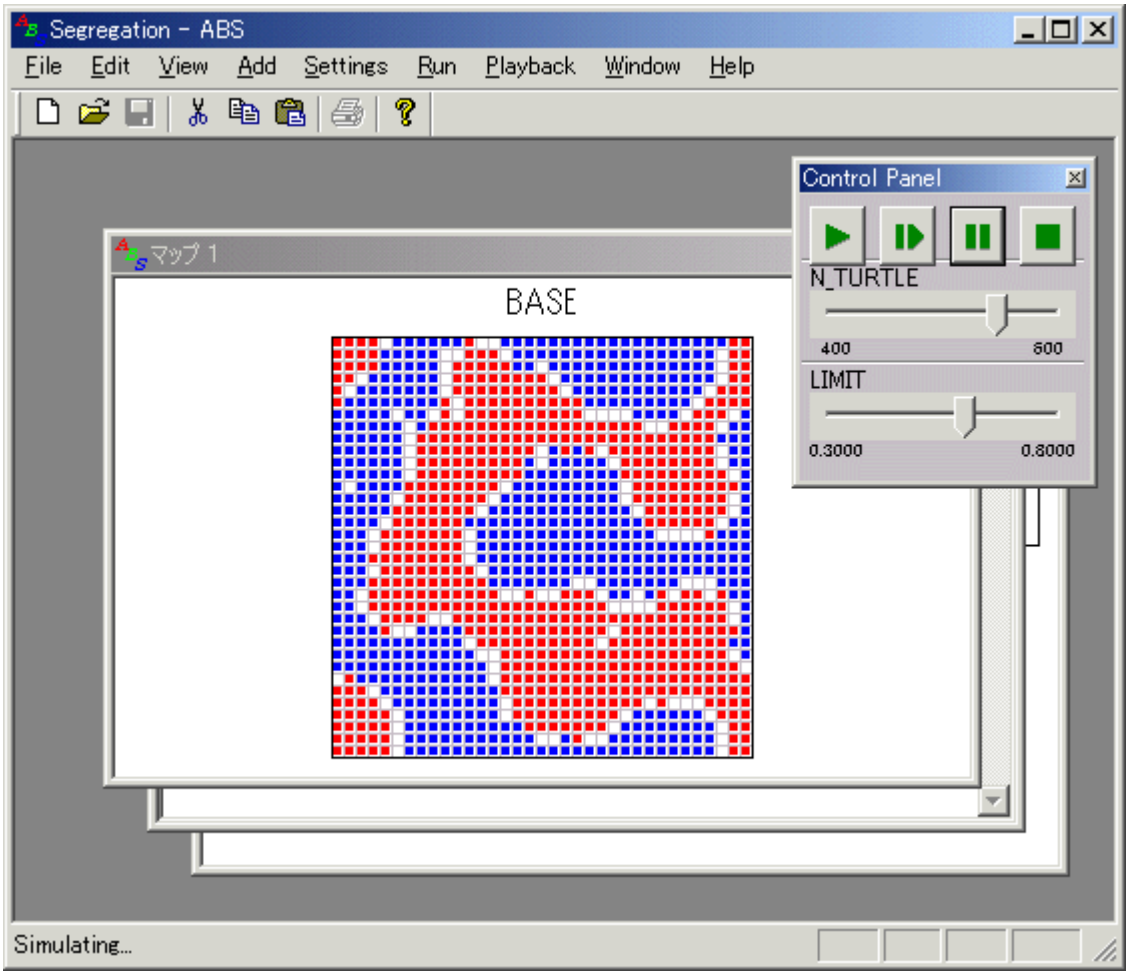
Pause, or all the turtles finish moving to locations where they are satisfied. See for yourself what results this simulation model leads to.

1.1.2 Sugarscape Model

A Simulation of an Anthill

(1) About This Simulation

This model simulates two types of ants swarming on a mound of sugar in an islandlike configuration. The settings are such that the red ants have a wide field of view (10 to 11 sites) and the blue ants have a narrow field of view (2 to 3 sites), and the red ants have large appetites (2 to 3) whereas the blue ants eat little (1.5 to 2.5). Also, there are initial assets of 10 to 13 as a common setting for both types of ants.



The sugar that serves as food is placed beforehand in islandlike mounds on the World map; the closer to the center of each island, the more sugar is available. Each ant consumes its appetite's worth of sugar at every step, so to get the most sugar possible, each one looks around, moves to the site with the most sugar, then grabs every bit of sugar in the site, which it hoards as its assets. Because the sugar in the World would eventually run out under these conditions, it is replenished a little at a time. Each ant merely seeks and moves to the location where sugar is most plentiful, but when seen overall, it looks just like the ants are moving in a swarm over mountains of sugar.

If an ant's assets are depleted, the ant dies. Conversely, if an ant stockpiles assets equal to at

least ten times its appetite, it reproduces.

You can also change these settings however you like, of course, but first try running the simulation with the original settings.

(2) Settings

Go into the Tutorial folder and open the Sugarscape.abs file. This makes a window like the one in the following figure appear.

Now let's try actually running it. To run it, use the Control Panel window. From the View menu, choose Control Panel.

This Control Panel has different buttons and sliders than the segregation model. Let's take a look at these, working from top to bottom.

Food Replenishment

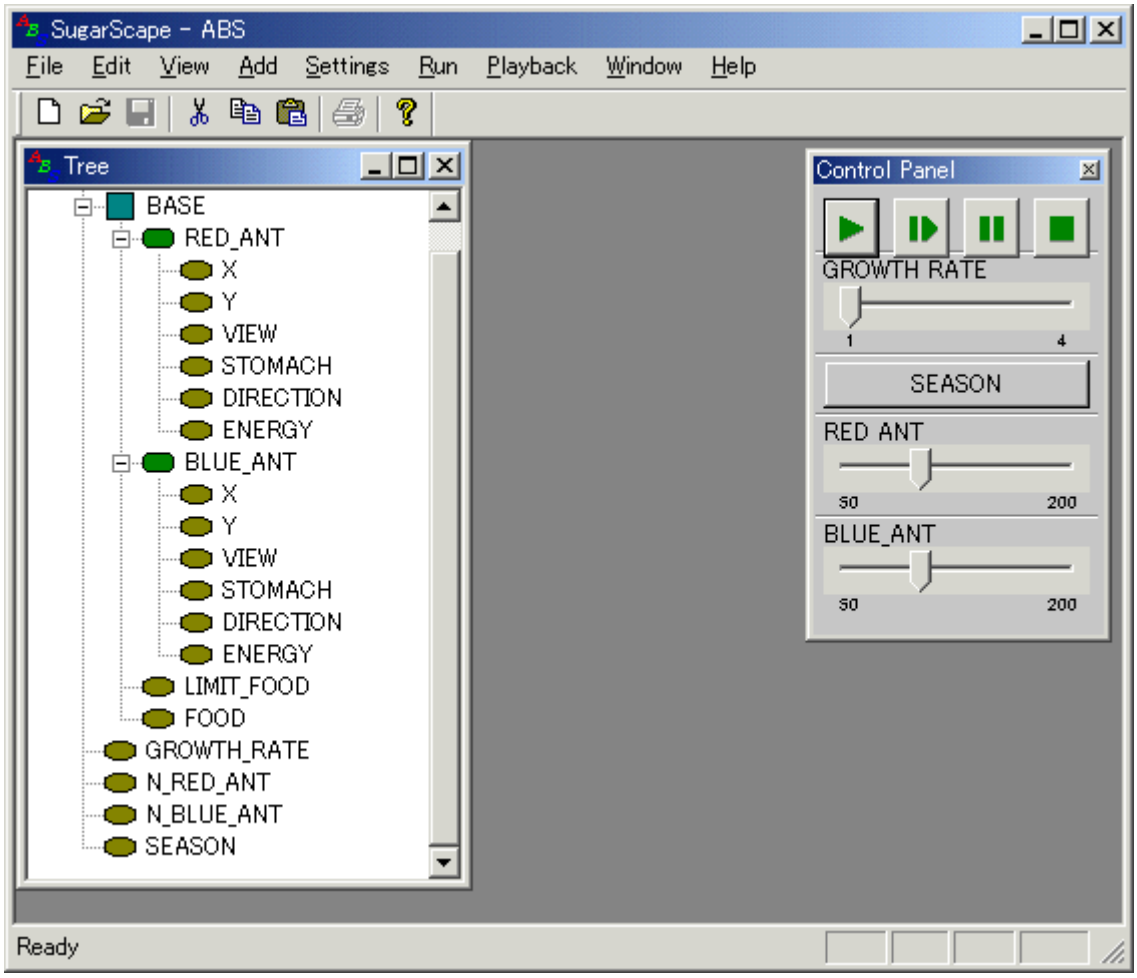
When the slider is all the way to the left, food is replenished at the rate of one per step. When it is all the way to the right, food is replenished at the rate of one per every four steps. Naturally, the farther to the right the slider is, the harsher is the environment for the ants.

Seasonal Change

When you select this button, the space is divided into an upper part and a lower part, and food is replenished only in one part. This simulates a lack of food in winter. Every 60 steps, the seasons in the upper and lower areas are reversed.

Number of Red Ants and Number of Blue Ants

You can use these sliders to set the starting number of each type of ant from 50 to 200. The



settings for these sliders must be made before you start the simulation.

Let's give it a try. In the Control Panel window, click the Run button. Did the following screen appear?
See for yourself how the settings on the Control Panel affect the simulation.

1.2 Making Changes

In the previous section you tried running some models yourself, but that was only able to run prepared simulations. Now let's try getting some different results by changing the settings.

1.2.1 Segregation Model ... A Simulation of Segregated Living Among Turtles

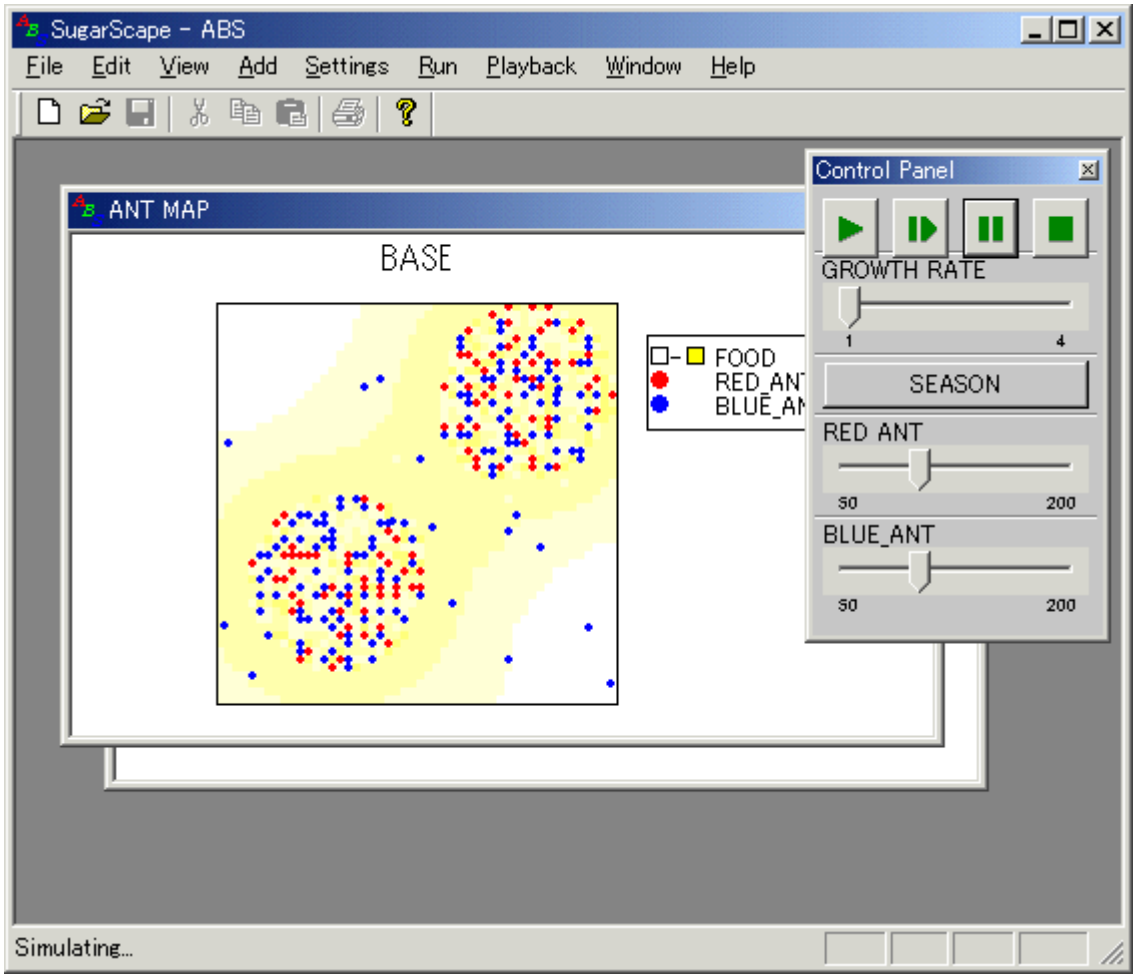
Making the Component Settings Again

Changing the Type of Space

In the initial stage, the turtles moved around on a square grid measuring 35 squares on a side. Let's try changing this to a hexagonal model. The procedure is as follows.

In the Tree window, right-click on twoDimensionalSpace. From the menu, select Properties.
Click Type of Space, then change Grid Model to Hexagon Model.

In the grid model, the turtles could only move in four directions; forward, backward, left, or right. But in the hexagon model, they move in six directions.



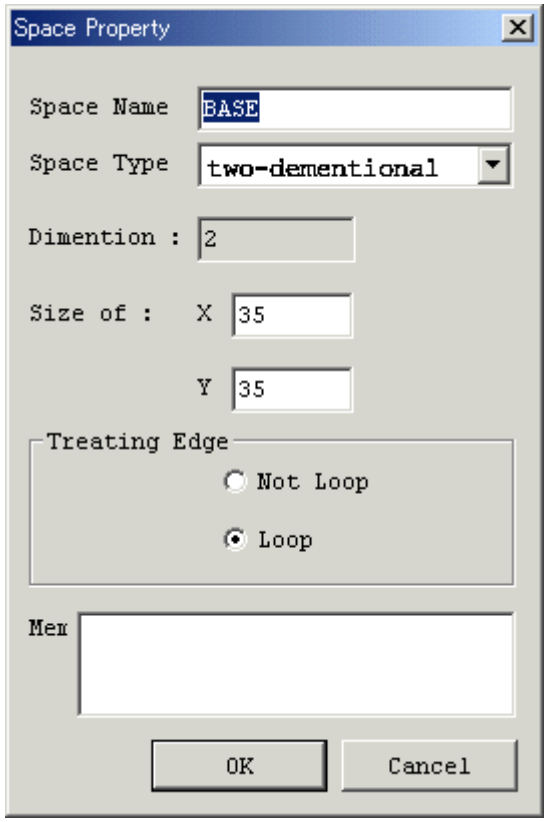
Making the Output Settings Again

Next, let's try modifying the output in various ways.

From the Settings menu, choose Output.

(1) Making the time-series graph lines bold and adding markers

Let's add markers to the apices of the bends in the lines of the time-series graph and make the lines thicker, making the graph easier to view. The procedure is as follows.



1. *From the list, choose Number of Turtles, then click Edit. This displays the Time-Series Graph Settings dialog box.*
2. *In the Graph Component List, select Happy Turtles, then click Edit.*
3. *Change the Line Width setting from "1pt" to "3pt", select the Show Markers check box, then click OK. You can make the settings in the same way for Unhappy Turtles as well.*

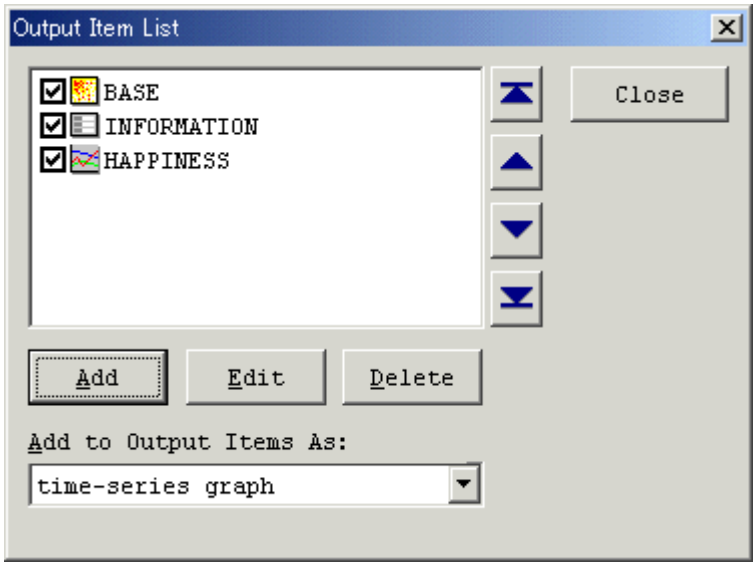
   Now you're ready again. Try clicking the Run button on the Control Panel.

1.2.2 Sugarscape Model ... A Simulation of an Anthill

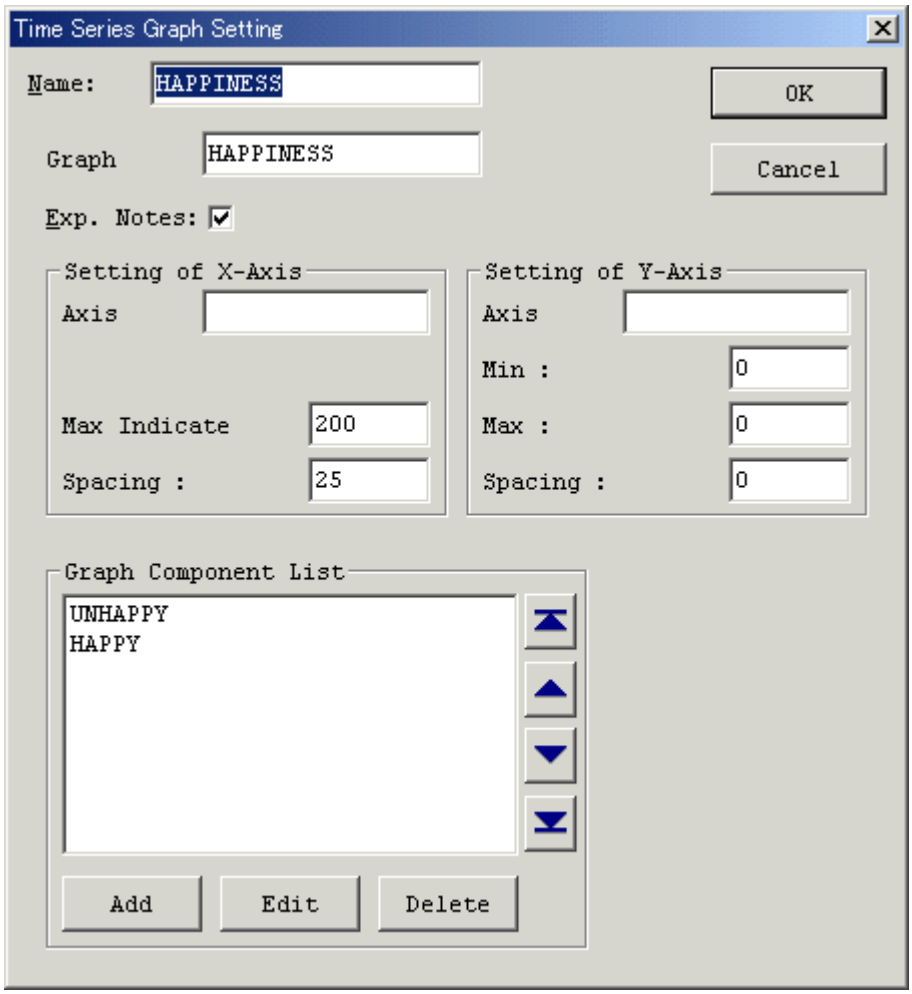
Making the Component Settings Again

Making the Control Panel Settings

You've already seen how you can use the buttons in the Control Panel window to change the settings for simulations in real time. Now let's try changing Number of Red Ants.



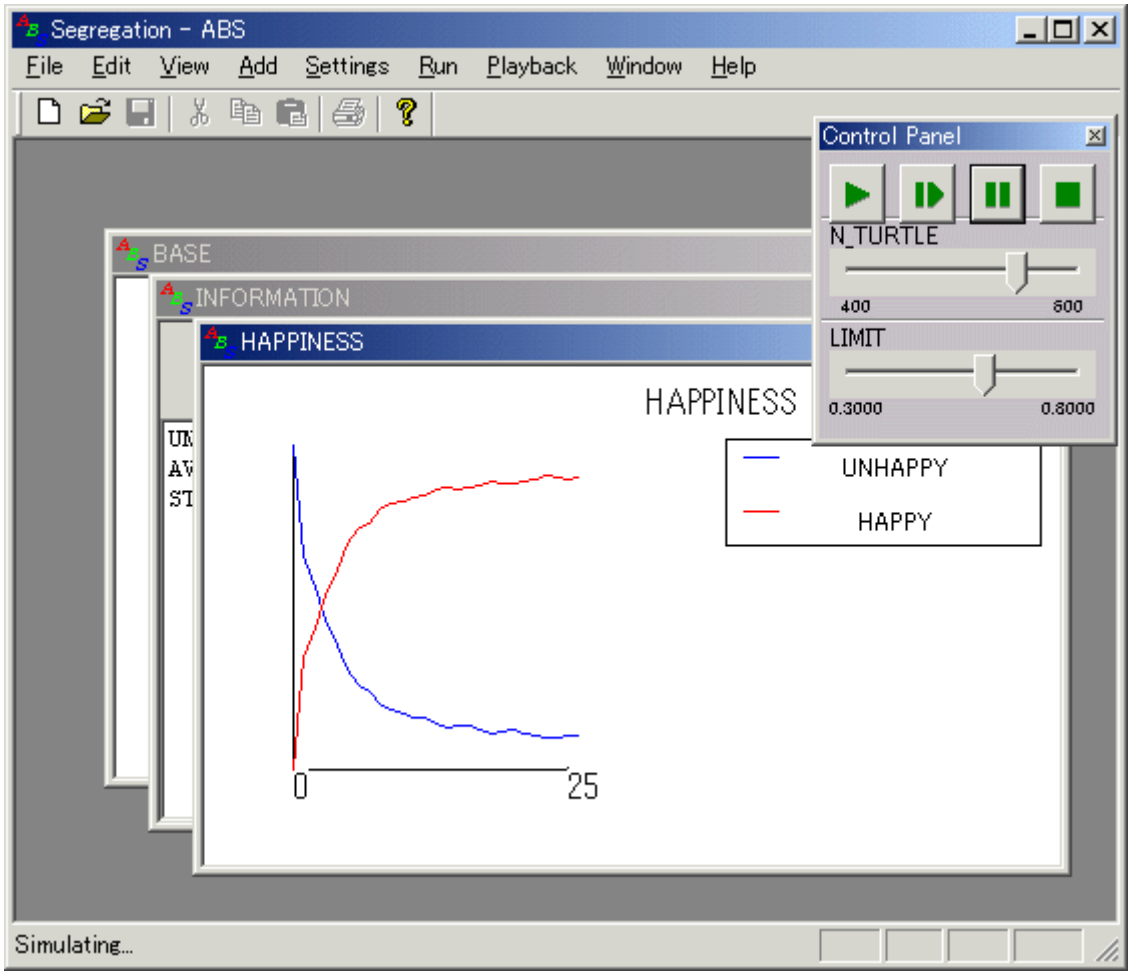
1. *From the Settings menu, select Control Panel Settings.*
2. *From the list, choose Number of Red Ants, then click Edit. A User Settings dialog box appears.*
3. *Change the range of "50 to 200" to "50 to 500", change Scale Interval to "50", then click OK.*



Now let's try running it. Try displaying the Control Panel window. Notice how the range has changed to "from 50 to 500" for just the number of red ants. So how does this change affect the simulation? Try running it yourself and see.

1.3 Constructing a Simple Model

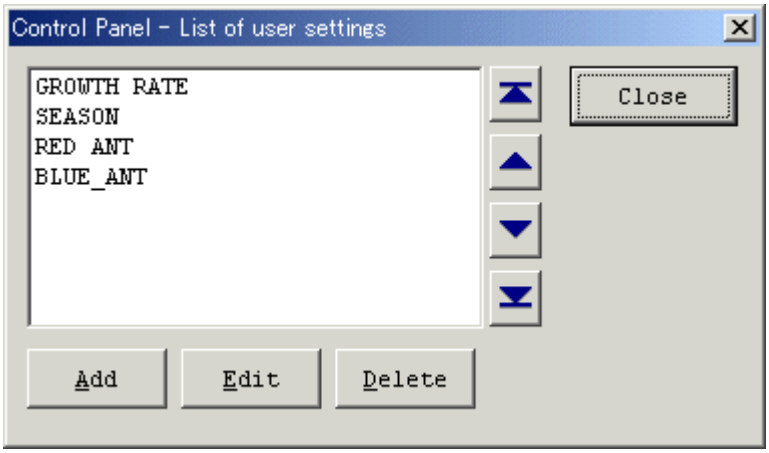
In this section, you'll learn about the basic elements and procedures for constructing an agent model from a completely blank state. Construction of a model usually follows a sequence like the one described following.



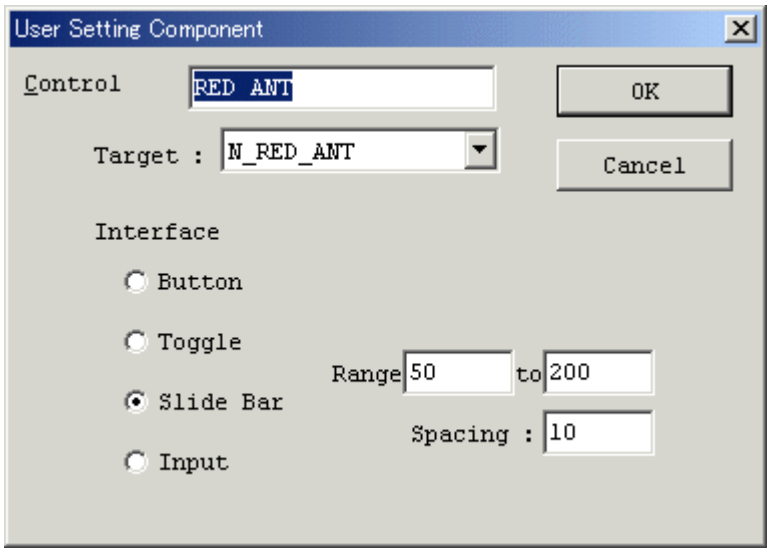
1. *Component placement and settings*
2. *Output settings*
3. *Describing agent rules*
4. *Running and debugging*

This list comes up many times during the creation process, so use it to get a general idea of what operation you're performing at the time.

This section also deals with the important programming concepts of conditional branches (If statements), methods of setting initial values, and debugging. Rules are still at an undeveloped stage, but beginners should familiarize themselves with the unique modes of expression and



ways of writing that are used in programming. If you already have a certain level of experience, you may safely skim through this section.



1.3.1 The ABS Programming Environment

First, start Agent Based Simulator. Next, on the menu bar, choose File, then select New. A screen like the one below appears.

The area on the left side is called the Tree window. The area next to the Tree is the World Agent Canvas. On the right side of the screen is the Control Panel window.

Tree

In *Agent Based Simulator*, the various elements used in simulations are collectively called "components". The component tree on the left side shows this hierarchical structure as a tree diagram, with the World agent always at the highest level. Arranged beneath the World hierarchy are the space, agent, and variable elements.

Use is the same as for Windows Explorer. Click the "+" or "−" symbol to the left of each element to display or hide the hierarchy under each.

Canvas

The World, space, and agent components can include other components within themselves (that is, in their lower their hierarchies).

The Canvas indicates this hierarchical relationship using icons, so it is synchronized with the Tree on the left side. Double-clicking on a component in the Canvas displays the included elements on the Canvas.

Clicking the World Canvas window displays the New Space, New Agent, and New Variable buttons on the right side. You can add a new component by choosing the corresponding New button, then clicking anywhere on the canvas.

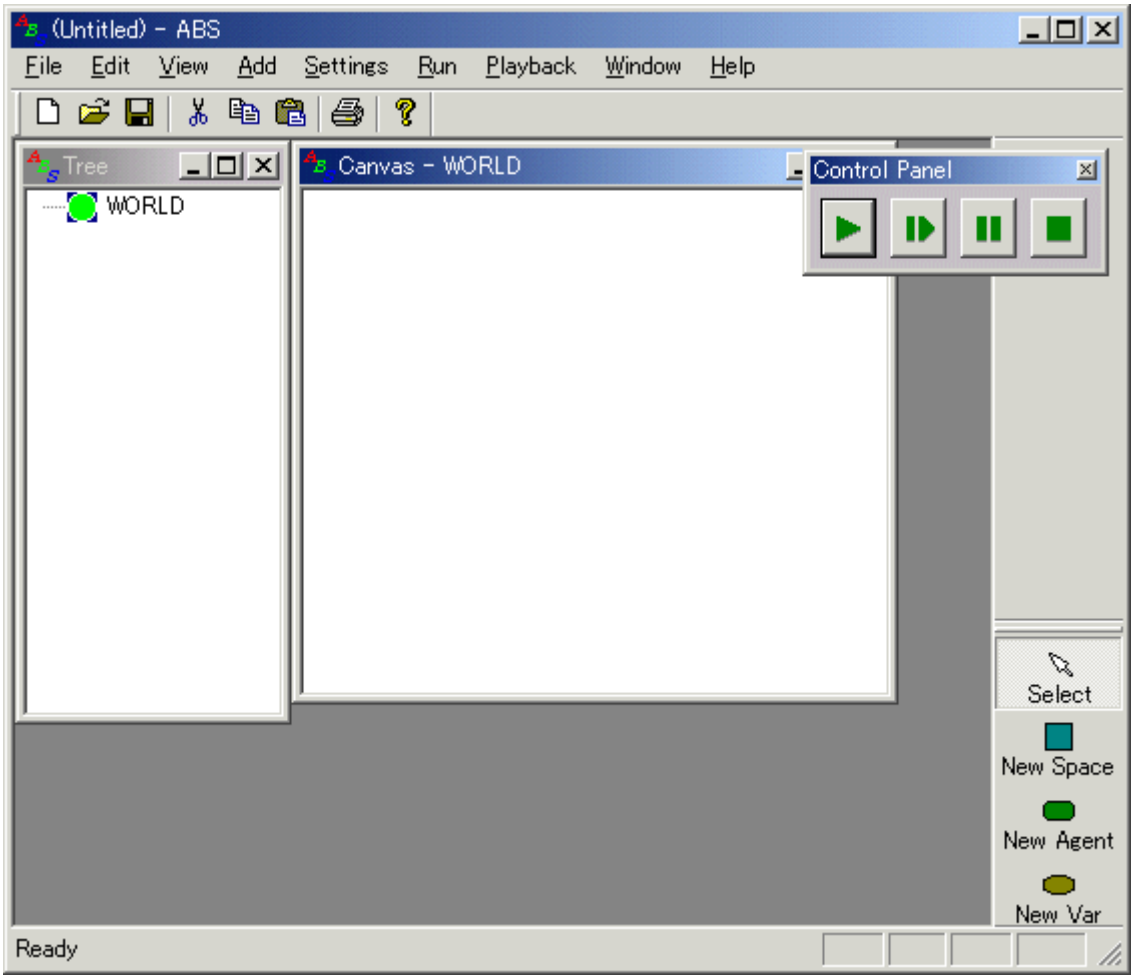
World Agent

World agent exists uniquely at the highest level of a simulation model. All other components

are placed in the hierarchy under the World agent to make up the simulation. Its name is "World", but it doesn't necessarily have to take up space, as in the real world. It's also possible to construct abstract models that take up no space.

Control Panel

Control Panel has buttons for running, stepping through, pausing, and stopping simulations. If you click the Run button when only an empty agent rule has been made (that is, immediately after you go to the menu bar, pull down the File menu, and select New), then not only nothing is displayed, but the Tree and Canvas are hidden. To return to the original state, click the Stop button.



Space

This is the space where agents and variables are placed. The present version of *Agent Based Simulator* supports only two-dimensional spaces, but support for three dimensions may be possible in future versions. Normally you use the Grid Model with its regular horizontal and vertical arrangement, but you can also use the Hexagon Model which is employed for simulations of strategy and the like.

The setting for Edge of Space determines whether coordinates wrap around to the opposite side when they exceed the boundaries of the space. When set to Loop, an agent that disappears from the right side appears again on the left side, like with a LOGO graphic turtle. Note that because this feature is effective only in the functions of *Agent Based Simulator*, processing code must be implemented in the program.

Agent

A component that acts and interacts in a simulation according to certain rules is called an agent. An agent acts on and is affected by other components. *Agent Based Simulator* makes it simple to place multiple agents and carry out simulations.

Variable

This is something like a container for storing the information and state of a component in the form of numerical values or text. It may be useful to consider it more or less synonymous with variables in mathematics, such as *x* and *y*.
What is unique about computer variables is that they are always typed. Before you use a variable, you must declare what type it is. Types include Integer, Double, and Text data types. It's necessary to use variables of the appropriate types, matched to the kind of information .

1.3.2 Adding a Component (Space)

1. Component placement and settings
2. Output settings
3. Describing agent rules
4. Running and debugging

In the component tree, right-click on World to display the context menu. Then select Add Space.
Selecting Add Space displays a Space Properties window. Set Space Name to "space", set Space Type to "Grid Model", leave the Space Size settings at 50 for both X and Y, and set Edge of Space to "Do Not Loop". When you have finished making the settings, click OK to close the window.

Now you're done creating a two-dimensional space using the grid model for the World agent. Make sure that "space" appeared under World in the tree, and on the World canvas.

1.3.3 Adding a Component (Agent)

In the Tree window, right-click "space". From the context menu choose Add Agent. The Agent Properties window appears. Change Agent Name to "turtle" and set Number of Agents to 1. When you have finished making the settings, click OK to close the window. This creates a turtle agent in the hierarchy under the space.

When you click the + of the turtle agent on the tree, you see that the variables included in the agent have been added automatically. X and Y indicate the coordinates of the agent's location in the two dimensions, with the upper-left point taken to be (0,0). Direction shows the agent's orientation in radians, so one revolution (360-degree) is 2π. Because the calculations are a bit troublesome, we will not use this variable here.

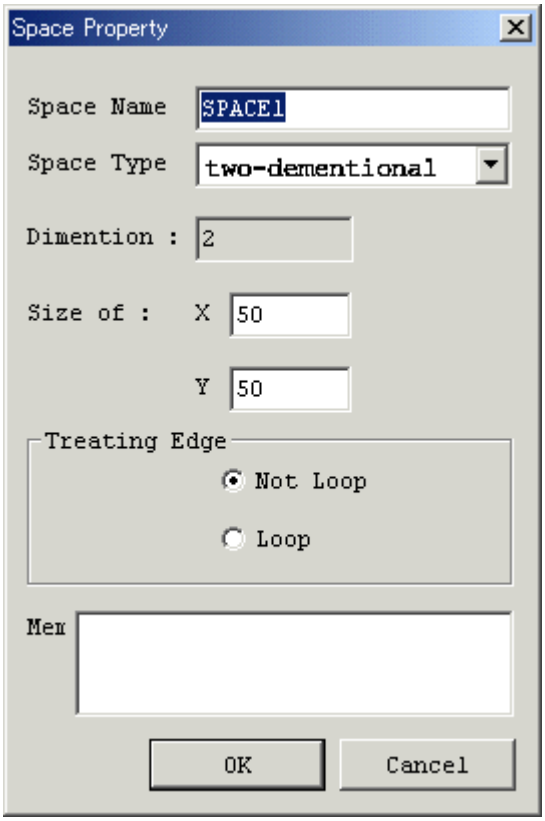
1.3.4 Adding Output Settings

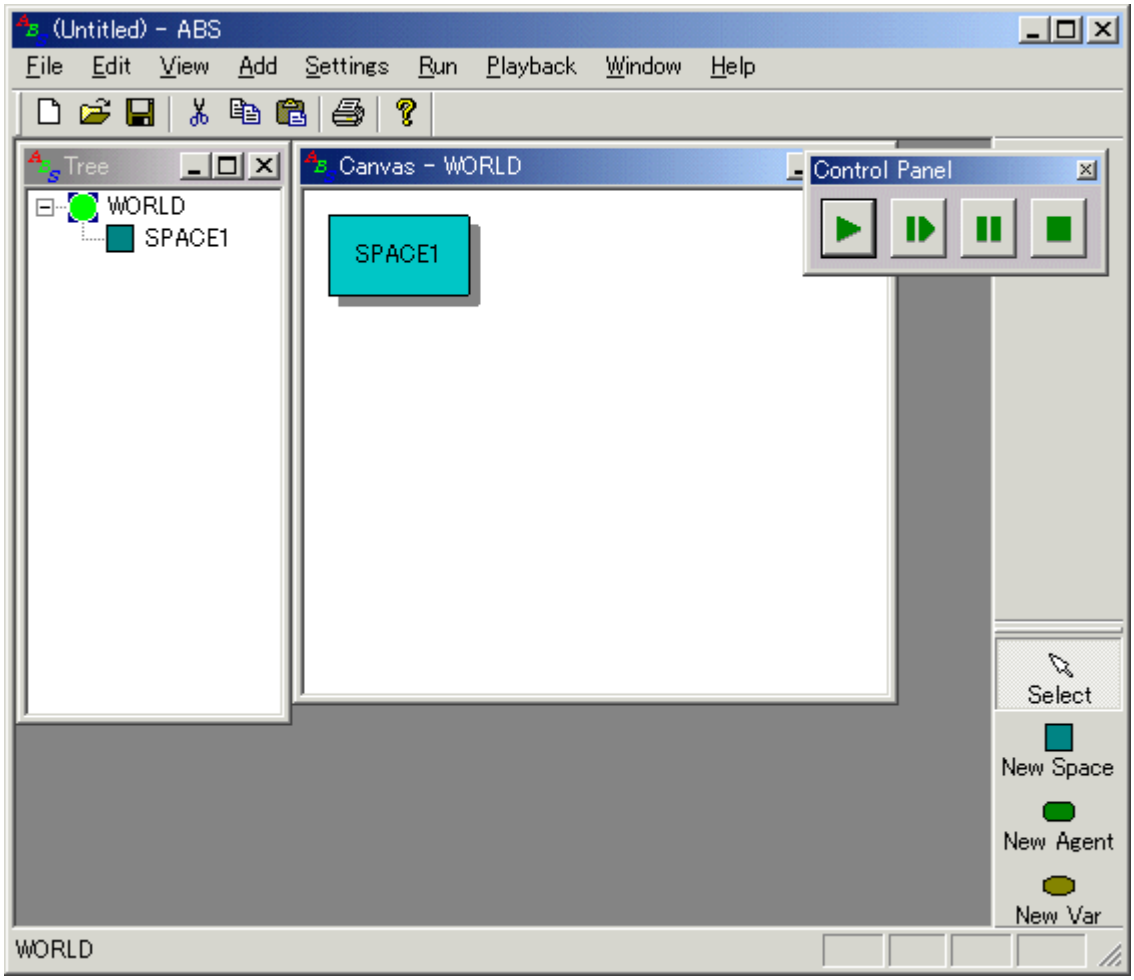
1. Component placement and settings
2. Output settings

You're now finished making the settings for a simple agent, but clicking the Run button in the Control Panel window still will not display anything (Click the Stop button to go back to the original state). To display something while running, you need to add output settings.

> ***Output settings are required to run a simulation***

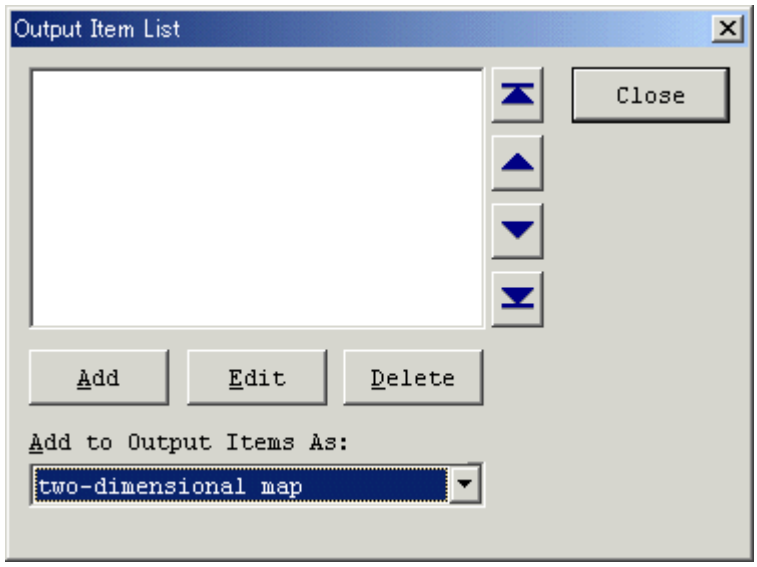
From the menu bar, select the Settings menu and choose Output. The types of output items include Time-series Graph, Bar Graph, 2D Map, Numerical Output, and File Output. From the drop-down combo box, choose 2D Map, then click Add.
The Two-dimensional Map Settings dialog box appears. Leave Map Name unchanged as "2Dmap_1" and Map Title unchanged as "space", and in the Map Component List click Add.
The Two-dimensional Map Component Settings dialog box appears. Change Component Name to "turtle", leave everything else unchanged, then click OK to close the dialog box. This adds "turtle" to the Map Component List.
In the Two-dimensional Map Settings dialog box, click OK to close the dialog box. When you go back to the Output Item List, you see that "2Dmap_1" has been added.





In the Output Item List, click Close to close the dialog box.

1.3.5 Running It (A Turtle that Does Nothing)



At the Control Panel window, try clicking Run. In this state, the agent still doesn't have any rules, so it just sits there and does nothing. Now, however, you've created the minimum of elements and state for making the agent move around.

At the Control Panel window, click Stop to quit the simulation. From the menu bar, click File to display the menu, then choose Save As. Name the program "prog01.abs" and save it.

1.3.6 Opening the Rule Editor

1. *Component placement and settings*
2. *Output settings*
3. *Describing agent rules*
4. *Running and debugging*

The present state isn't very interesting, so let's apply some rules to the agent.

We'll add these rules to prog01.abs, which you created in the previous section. If you are starting again from this section, then double-click the prog01.abs file you saved to open it.
In the component tree, right-click the Turtle agent to display the context menu. From the menu, select Rule Editor. This displays the Rule Editor window for the agent.

You see that the window already has two items, Agt_Init and Agt_Step. Agt_Init is an initial rule that is executed only once, when an agent is created in a simulation. Agt_Step is an execution rule that is executed at every step when the simulation runs. The braces ("{}") indicate respectively the beginning and end of the rule. The necessary statements are written inside the braces.

> ***"Agt_Init" is an initial rule executed only once, when an agent is created.***

> ***"Agt_Step" is an execution rule, executed at every step when a simulation runs.***

1.3.7 Writing the First Rule

Now let's try writing the first rule.

Prog02.abs (Turtle agent rule)

```
Agt_Step{
    my.X=my.X+1
}
```

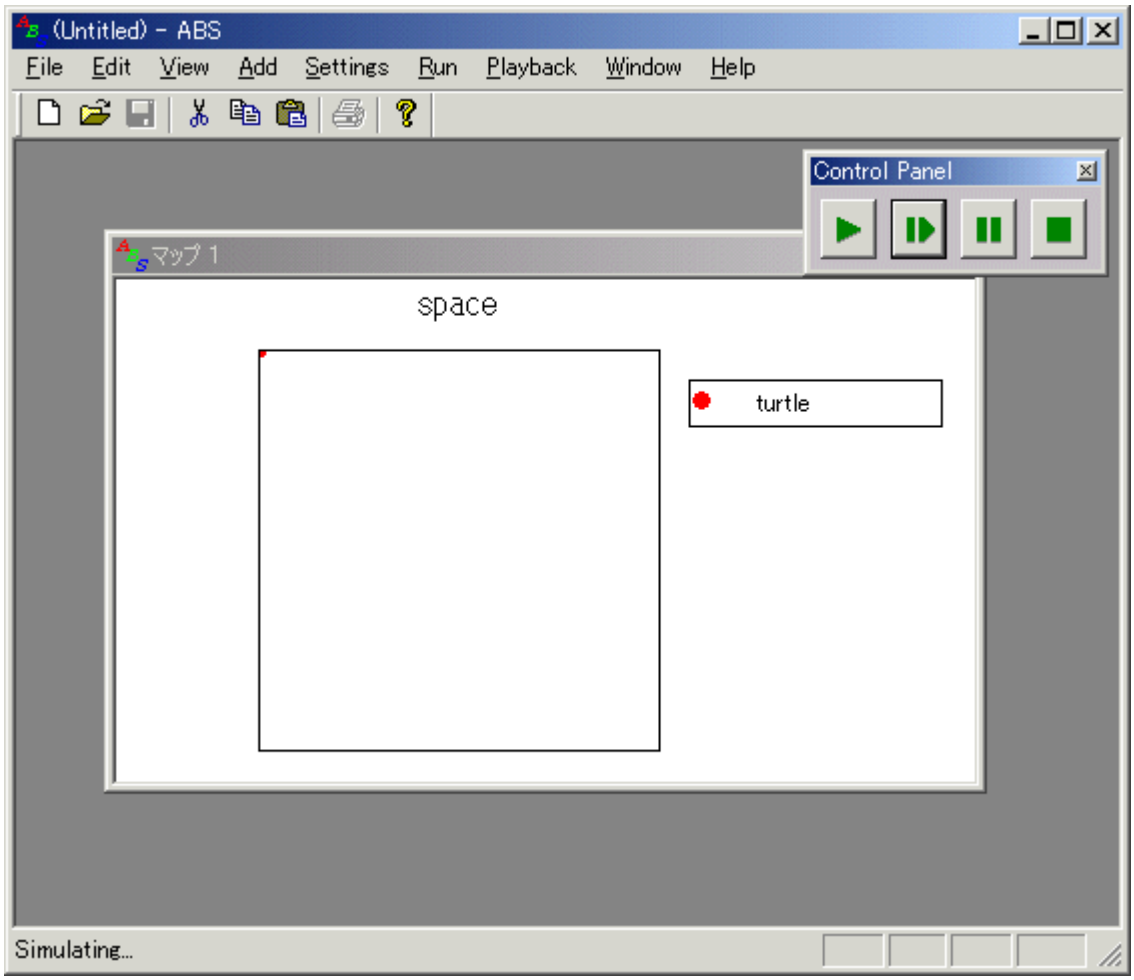
When you entered my., a window for variables such as X, Y, and DIRECTION appeared. Here, we'll use X, so use the arrow keys to choose X, then press Enter. The my. is a special notation that points to the agent itself. Here, my.X indicates the X variable included within itself.
At first glance, this rule may appear to be mathematically incorrect, but remember that in a program, it is used not as an equality statement, but as an assignment statement. That is, it signifies that the information on the right side of the equal sign is to be assigned to the left side of the equal sign. If my.X has a value of 1, then after rule execution, my.X becomes 2.
To make code more readable, add spaces between variable names, operators such as the equal sign, +, and –, and other words.

> ***"my." is special notation pointing to the agent itself.***

> ***The equal sign "=" in a rule is an assignment statement.***

Steps

ABS simulations are executed in units of time called "steps". At each step, all Agt_Step rules (execution rules) included under World are executed in random order. When this finishes, the step is incremented.



1.3.8 Running It (A Bullet Turtle that Disappears from the Map)

When you finish writing the rule, go to the Control Panel window and click Run. If there is an error, check the highlighted line for an incorrect word.

When the program runs correctly, the value of the X coordinate increases by 1, so the turtle on the left edge moves to the right side, and finally moves off the two-dimensional map and disappears from view. Even after it disappears from the map, the turtle keeps moving to the right, so click Stop to stop it.

At the Control Panel window, click Stop to quit the simulation. From the menu bar, click File to display the menu, then choose Save As. Name the program "prog02.abs" and save it.

1.3.9 Making an Agent that Moves Back and Forth Over the Map

(1) Adding a Variable to the Agent

Now let's try modifying the bullet-turtle rule, reworking it so that the turtle now moves back and forth over the two-dimensional map. Consider for a moment how we should express this

rule. It should be able to change direction when it reaches the edge of the screen, but the orientation cannot be determined from just the agent's X and Y coordinates. In this example, we are not using DIRECTION, which controls the orientation.
We'll add a new variable to the turtle agent that indicates the direction of advancing along the X axis as a positive or negative value.

In the component tree, right-click the Turtle agent to display the context menu. From the menu, select Add Variable. The Variable Properties dialog box appears. Enter DIRX for Variable Name, and Integer for Variable Type. Leave Number of Dimensions set to 0. Then click OK.

(2) Adding a Conditional Branch Rule

Before we write the code, let's write out the rule in text form.

- Initial rule : Assign 1 to DIRX.
- Execution rules : If the X coordinate is 0 or less than 0, then assign 1 to DIRX (changing the orientation to the front).
- If the X coordinate is 49 or greater than 49, then assign −1 to DIRX (changing the orientation to the back).
- Add the value of DIRX to the X coordinate.

When we write the code for this, it looks like the following.

Prog03.abs (Turtle agent rule)

```
Agt_Init{
    my.DIRX=1
}
Agt_Step{
    If my.X <= 0 Then
        my.DIRX=1
    End If
    If my.X >= 49 Then
        my.DIRX=-1
    End If
    my.X=my.X+my.DIRX
}
```

To review what you learned earlier, Agt_Init{} is a rule that is executed only once, when an agent is created. The new variable is given a value of 0 in its initial state, so unless the initial rule assigns a value "1" or "−1" to DIRX, the turtle won't move.
Something newly added here is a conditional-branch rule. This is written with this syntax; If (*condition*) Then (*rule carried out if the condition is fulfilled*) End If. The portion from Then to End If may be any number of lines. It is usual to use tabs to indent this portion so that the branched structure of the conditional expression is apparent. Also, rule statements are not case-sensitive (upper case and lower case are not differentiated). This means that my.X and My.X are actually processed in the same way.

> ***"If (condition) Then (rule carried out if the condition is fulfilled) End If"***

> ***Rule statements are not case-sensitive.***

(3) Running It (A Turtle That Moves Back and Forth)

When you finish writing the rule, go to the Control Panel window and click Run. If it runs correctly, the turtle continues moving back and forth, changing direction at the edges of the map. As an exercise to apply this, try adding DIRY to indicate the direction of the Y coordinate as well, creating an agent that moves diagonally. The agent rule of the answer may look like the following.

Prog04.abs (Turtle agent rule)

```
Agt_Init{
    my.DIRX=1
    my.DIRY=1
}
Agt_Step{
    If my.X <= 0 Then
        my.DIRX=1
    End If
    If my.X >= 49 Then
        my.DIRX=-1
    End If
    my.X=my.X+my.DIRX
    If my.Y <= 0 Then
        my.DIRY=1
    End If
    If my.Y >= 49 Then
        my.DIRY=-1
    End If
    my.Y=my.Y+my.DIRY
}
```

1.3.10 Adding More Turtle Agents

(1) Creating Multiple Agents

Now that you've made an agent that moves diagonally, let's try creating multiple agents. However, no matter how large we increase the number, if we place all the agents at the same location at the start, they will all move the same way. That isn't very interesting, so let's try changing where each one is placed at the start.

In the component tree, right-click the Turtle agent to display the context menu. From the menu, select Properties. The Agent Properties dialog box appears. Here, set Number of Agents to 3, then click OK.

> ***Use Agent Properties to make the setting for the number of agents.***

(2) How to Place Individual Agents at Different Initial Locations

We want to start each agent at a different location. To do this, we need to assign different initial values to the X and Y variables that indicate the space positions of the agents. How do we do this?

There is a feature that lets you assign individual initial values to variables. In the component tree, right-click the X variable for the Turtle agent to display the context menu. From the menu, select Initialize. The Initialize dialog box appears.
There are three Turtle agents, numbers 0, 1, and 2. Assign these values of 5, 10, and 15, respectively. If the numerical values are obscured, drag the right edge of the X item name to adjust the horizontal width. When you have finished making the settings, click OK to close the window.

Now when you run it, you see interesting movement, even with these simple rules.

> ***Individual initial values are assigned to agents with Initialize.***

(3) How to Assign a Nonzero Value to Agent Variables in a Batch

Now let's say we want the Y coordinates for all the agents to start at 5. What should we do in this case? There are two possible answers. One way is to add my.Y = 5 to Agt_Init{} for the Turtle agents, as we described in the section on the DIRX setting.
Another method is to use Set Default. This is different from Initialize, which we saw earlier — instead, it is a feature for assigning initial values to variables in a batch.

In the component tree, click the Y variable to select it. Then, from the menu bar, go into the Settings menu and choose Set Default. The default value should be set to 5 (• ¨ Prog05.abs).

> ***Set Default assigns initial values to agents in a batch.***

1.3.11 If the Simulations Doesn't Run Correctly

1. *Component placement and settings*
2. *Output settings*
3. *Describing agent rules*
4. *Running and debugging*

The process of identifying the causes of program errors and correcting them so that the program runs properly is called "debugging". No matter how much care and planning you put into crafting a program, it rarely runs flawlessly the very first time. Something almost always occurs; for example, the program may stop because of a syntax error, or it may not run as expected. Mistakes and errors are an unavoidable part of programming, even for seasoned programmers. However, being able to perform appropriate troubleshooting when problems occur, seems to lead to proficiency in programming faster than trying to prevent errors before they occur.

Computers Operate Through Logic

People are ambiguous, but computers operate entirely through logic. Unless some very special steps are taken, there are never any exceptions where a computer will depart from logic. This

means that any computer error always has a clear-cut cause. If results are not as expected, it is never a case of the machine being in a bad mood or not liking the operator.

To eradicate errors, it is important first of all to isolate and identify the problematic area according to computer logic. The examples below are some errors that beginners are particular likely to make.

(1) Syntax Errors in Rules

If operation is different from what you expected or if a warning message appears, the first to look for is a syntax error in one or more of the rules. These errors are not limited to beginners. Even skillful programmers frequently experience syntax errors caused by carelessness.

Remedy1

If Agent Based Simulator discovers an error before execution, it displays a warning message indicating the line where the problem occurred. In almost all cases, the error is caused by a mistake in how the line is written, so check the points like the following.

- Spelling mistakes in variable and function names
- Missing spaces around commands, variables, and operators

(Tip) The spaces between words in the program list have an important meaning. If the words are connected, then may not be recognized correctly.

Remedy2

Include the DebugStr() function in the rules to verify the values of variables. For example,

```
DebugStr(World.NumberOfTurles)
// The value of the World.NumberOfTurtles variable appears
// on the Debug Screen.
```

(2) Incorrect Output Settings

With *Agent Based Simulator*, nothing is displayed during execution unless output settings are made. Also, if only one type is displayed even though two types are supposed to appear, or if the behavior of graphs or numerical values is different from what it expected, it often means that there is a mistake in the output settings. Often no warning is displayed for such errors, so it can be difficult at first to discover where the problem is.

Remedy

Output settings are essential for obtaining any kind of result during execution. Check the output settings to make sure the Item Name and Component Name settings for the elements are correct. If there are not enough output elements, in almost cases a Component Name setting is incorrect.

(3) Incorrect Component Properties

If there's nothing wrong with the rules but operation is nonetheless incorrect, it's necessary to look for an error in the properties of the components, such as the number of agents created and their initial values.

Remedy1

Make sure the value of each property is set correctly.

Remedy2

Remember that there are a number of methods for determining the initial values of components.

- Batch settings of numerical values for all components are made with Set Default.
- Numerical values of individual components are set separately with Initialize.
- Numerical values can also be assigned by assignment statements in the component rules.

When initial values are set using all the preceding methods, the settings take priority in this sequence; 1) component rules, 2) Initialize, and 3) Set Default. Make sure that the values of the settings are not being changed somewhere.

1.3.12 Conclusion

Here is what you've learned in this section.

1.3.13 Terms and Techniques

- Component tree
- Canvas
- World agent
- Control Panel
- Space
- Agent
- Variable
- Adding space to World
- Adding agent
- Adding output settings
- Displaying Rule Editor
- Two types of rules (Agt_Init{} and Agt_Step{})
- How a component references itself (my.)
- Conditional branch statements (If...Then...End If)
- Adding variables to agents
- Creating multiple agents
- Assigning initial values to variables individually (Initialize)
- Assigning initial values to variables in a batch (Set Default)
- Debugging

1.3.14 Let's Review

- Have you mastered the basic structural elements in the *ABS* programming environment?
- Do you understand the flow of the basic steps for creating an *ABS* program; Component locations and settings ... Output settings ... Describing agent rules ... Running and debugging?
- Did you try making *Agent Based Simulator* settings yourself while referring to the text? Did the programs run as expected?

1.4 Making Modifications for a Slightly More Complex Model

In this section, you'll add increasingly complex elements while modifying the rule for the turtle that moves back and forth. The programming concepts covered include declaration of variables, loop control, random numbers, functions, and arrays. So far the examples we've seen have been somewhat mechanical, but incorporating random numbers in the rules makes it possible to make agents move separately. This makes the examples more like actual agent models. This section also contains numerous techniques and tricks for using *Agent Based Simulator*, so be sure not to overlook them.

1.4.1 Resetting the X and Y Variables to Their Original State

In Prog05.abs, we set the initial values and default values for the X and Y variables, so let's return these to their initial state.

In the tree, right-click the X variable to display the context menu. Next, from the context menu, choose Initialize to return the values of 5, 10, and 15 for the respective X variables to 0. In the tree, click the Y variable to select it, then from the menu bar, go into the Settings menu and choose Set Default to return the setting to the default value of 0.

1.4.2 Using World

When there is a large number of agent (for example, 100 or 200), how can we assign initial values to them efficiently?
If they are arranged regularly, then it should be enough simply to write a rule somewhere. However, in the rules for an agent, although local information for the agent itself and its surroundings are determined, this isn't practical for manipulating multiple agents as a group (More accurately, this is structurally unsound). What we use at such times is World, at the highest level. World is also an agent, so you can also write rules for it. However, what is special is that World rules are often used in cases of batch processing that affects all agents in the hierarchy.

> ***World agent rules are often used to perform batch processing that affects agents in the hierarchy.***

There is also common rules although we are not using them here. To display the Common Rule Editor, go into the View menu and select Common Rule Editor. Because these rules can be referenced either from agents or from World, it is sufficient to write a computational expression (function) used by both agent rules and World rules; for instance, a function generating a random number in a certain range.

> ***Common rules can be referenced both from agents and from World.***

Let's consider how to place Turtle agents with their X coordinates spaced three sites apart. World need to know the number of agents created, and to assign the values to the X variables for each turtle agent. Write this into the Agt_Init{} rule for World.

Prog06.abs (World agent)

```
Agt_Init{
    Dim i as integer
    for i = 0 to _CountAgent(World.space.turtle) - 1
        World.space.turtle.X(i) = i * 3
    next i
}
```

1.4.3 For Variables Used Only in Rules, First Define the Type

What appears first is a Dim statement. This is called a declaration statement. It's used to define a type for a temporary variable used only within a rule. When execution of the rule ends, the variable is deleted. Such variable is called "local variable". Local variables are used differently from variables in the component tree, which continue to maintain their value. Here, we'll define a variable of Integer data type called "i" for accessing an individual agent.

> ***Temporary variables (local variables) used only within rules are declared with a "Dim" statement.***

1.4.4 Loop Control

The next topic is the For...Next statement. This is called a loop-control statement. It's used to repeat the enclosed commands the specified number of times. The number of times is specified as follows.

```
For variable name = starting number to ending number Step increment per iteration
    looped operation
Next variable name
```

The loop-statement variable "i" is ordinarily increased by one with each iteration, so you can usually omit Step. When Step -1 is used, the value is decreased by one with each iteration. When you write the looped operation, indent with a single tab to make it easier to understand the structure.

1.4.5 Determining the Number of Created Agents

In *Agent Based Simulator*, the special function _CountAgent() is used to determine the number of agents created. When certain data is given to a function, the function returns a value as result. Some functions are built in. You can also define your own original functions. With _CountAgent(), when you specify an agent in the parentheses, the function returns the number of agents as an integer.

> ***When certain data is given to a function, the function yields a specific return value.***

1.4.6 How to Specify Components

In specifying an agent in the parentheses, the hierarchical relationship with World is expressed by separating the names with periods ".". This means the Turtle agent is specified as "World.space.turtle". This method of expression is used in many places, so you should remember it.

> ***When specifying a component, state the hierarchical relationship, beginning with World.***

> ***Periods (".") are used to indicate the hierarchical relationship.***

1.4.7 Accessing an Individual Agent

Obtaining the information that an individual agent holds requires a bit of extra work. This method of expression is also frequently used, so you should remember how to use it.
To start with, created agents are assigned sequential IDs, beginning with 0. The variables in an agent are stored in an array, and are called in the form of the variable name (agent ID). For instance, The X coordinate of a Turtle agent having an ID of 4 is expressed as "World.space.turtle.X(4)".
Take a look at Prog06.abs. The variable "i" starts at 0, is looped to the number of agents −1, and the value of i×3 is assigned to each X coordinate.

> ***Agents are assigned sequential IDs, starting at 0.***

Array variables

When a large amount of data must be handled at one time, naming each variable individually would be an onerous task. When assigning the test scores in five subjects for ten people, for example, creating individual variables for each person and each subject, such as Ja1, En1, Ma1, So1, Sc1, Ja2, En2, Ma2, So2, Sc2,..., would be too inefficient. Moreover, if the number of persons were to change, it would become impossible to cope with the change.
Array variables are used in cases like this. An array variable uses the form of variable name (ID), and can be referenced simply by supplying the ID number in the parentheses. Applying to the test scores for five subjects as an example, the array variables might be Ja(1), En(1), Ma(1), So(1), Sc(1), Ja(2), En(2), Ma(2), So(2), Sc(2),... . With this method, all we have to do is specify Ja(i), En(i), Ma(i), So(i), and Sc(i) and use the value of "i" with a For...Next loop.
With *Agent Based Simulator*, the variables that agents have are automatically made array variables. Also, when you add a variable to a space, a two-dimensional array in the form of a grid matched to the size of the space is created. The two-dimensional array is specified as *variable name (X coordinate, Y coordinate)*.

1.4.8 Running It (A Large Number of Regular Turtles)

Now let's set the number of agents at six and try running the simulation. You see that the turtle agents are arranged at regular intervals, as specified by Agt_Init{}.

1.5 Adding Random Factors to Agents

So far we've covered how to assign regular initial values. However, the results still seem a bit mechanical, and not much like multi-agents. Now let's try adding a random element to the initial rule.

1.5.1 Placing Agents Randomly in a Space

Placing agents randomly in a space is fairly simple. In *Agent Based Simulator* we use the built-in agent function _RandomPutAgent(). The first item in the parentheses specifies the agent to place. The second item specifies whether placement of multiple agents in a single cell is permitted (True or False). Because all functions return a value, the correct use is along the lines of i=RandomPutAgent(), but in this case the important thing is the random-placement feature, and the return value is not needed. In cases where the return value is not used, the assignment statement is frequently omitted, as in the following rule.

> ***"_RandomPutAgent()" places agents randomly.***

Prog07.abs (World agent)

```
Agt_Init{
    _RandomPutAgent(World.space.turtle, False)
}
```

1.5.2 Adding Random Factors to Variable Values

The Rnd() function is used to assign random values to variables. Rnd() generates a random number greater than or equal to 0 and less than 1. In many cases, however, a random integer is required. This can be obtained by using Rnd() in combination with Int() to truncate the portion to the right of the decimal point, as in the following example.

```
i = Int(Rnd() * 5 )
```

In this case, the variable "i" is assigned an integer value of from 0 to 4. If you want a value from 1 to *a*, you can use i=Int(Rnd()*a)+1.
_RandomPutAgent() which we saw can be replaced as following code.

Prog08.abs (World agent)

```
Agt_Init{
    Dim i as integer
    For i = 0 to _CountAgent(World.space.turtle) - 1
        World.space.turtle.X(i) = Int(Rnd()*50)
        World.space.turtle.Y(i) = Int(Rnd()*50)
    Next i
}
```

Now let's also try making the direction random. The variables DIRX and DIRY must be added to the agent in advance. Also, let's remove the remaining initial rule for the Turtle agent. You'll notice that the complicated expression "-1+(Int(Rnd()*2)*2)" appears in this program. This is a programming technique for obtaining a result that is only either –1 or 1.

> ***"i = Int(Rnd()*a+1)" obtains a random integer from 0 to a.***

Prog09.abs (World agent)

```
Agt_Init{
    Dim i as integer
    For i = 0 to _CountAgent(World.space.turtle) - 1
        World.space.turtle.X(i) = Int(Rnd()*50)
        World.space.turtle.Y(i) = Int(Rnd()*50)
        World.space.turtle.DIRX(i) = -1 + (Int(Rnd()*2) * 2)
        World.space.turtle.DirY(i) = -1 + (Int(Rnd()*2) * 2)
    Next i
}
```

Prog09.abs (turtle agent)

```
Agt_Init{
}
```

1.5.3 Changing Execution Rules for Agents

Now you've assigned the agent's location and orientation randomly. Next, as a practical application of this, let's try adding a random factor to the agent's execution rules (Agt_Step). In our programs so far, the direction changed only when Turtle agents reach to edge of space. Now let's make the orientation change randomly.
In the execution rules for the Turtle agents (Agt_Step), write a rule to change the direction at random before the determination of whether a border has been reached.

Prog10.abs (turtle agent)

```
Agt_Step{
    if Int(Rnd()*10) == 0 then
        my.DIRX = -1 + Int(Rnd()*3)
        my.DIRY = -1 + Int(Rnd()*3)
    end if
    if my.X <= 0 then
        (The rest is the same)
```

The direction changed each iteration, the agents would zigzag all over the place, so we added an If statement to make the direction change only one time out of ten on average. Unlike the earlier example, the If statement obtains a value of either −1, 0, or 1. This makes the agents occasionally appear to stand still.

> ***"If Int(Rnd()*A) == 0 Then...End if" causes a branch with a probability of 1/A.***

1.6 Creating a Space That Wraps Around

Space that is looped (wraps around) is a coordinate system used by LOGO graphic turtles and the like. The top and bottom of the screen are connected, and so are the left and right sides. For example, when an agent disappears off the right side of the screen, it reappears on the left edge. This coordinate system is useful when simulating a space like a ball. However, it takes a little extra work to handle it with *Agent Based Simulator*. Let's take a look at the steps and rules that are involved.

So far, in Prog××.abs, we used If statements to make an agent change direction when it reached the edge of the map. Now we'll make the space wrap around and eliminate the map-edge processing code.

1.6.1 Space Component Settings

First, in the *ABS* Space Properties dialog box there is an option for selecting either Loop or Do Not Loop. To make the space wrap around, you must first select the Loop option. However, because this is valid only for built-in functions related to space, selecting Loop is not enough to establish the conditions for actually looping.

> ***The Loop setting in the Space Properties dialog box is not enough by itself.***

1.6.2 Creating a Function to Adjust the Coordinate Position

What we need to do now is to prepare another rule to adjust the coordinate position of the agents. However, because the rules themselves are starting to get lengthy, and because we'll be able to find other uses for this adjustment rule, let's try using a user-defined function.
A user-defined function is a function that you can define any way you like. You use Function() or Sub() for this. Function() and Sub() are differentiated in use as follows.

- *When a return value is required* ..... Function()
- *When a return value is not required*..... Sub()

User-defined statement format for Function

```
Function function name (argument name as argument type) As return-value type {
    variable type declaration block
    execution block
    Return(variable name)
}
```

User-defined statement format for Sub

```
Sub function name (argument name as argument type) {
    variable type declaration block
    execution block
}
```

Important : You can give a function any name you like, except reserved words, already-declared variable names, and already-declared name definitions. Using such illegal names can cause Agent Based Simulator to become confused.

Because the adjustment rule requires a return value, we have to use Function statement. You can write it at any location in the Rule Editor except inside Agt_Init{} or Agt_Step{}. Add the following user-defined function after Agt_Step{} for the Turtle agent. When you then eliminate the map-edge processing portion from the execution rule (Agt_Step), you end up with Prog11.abs.

> ***User-defined function — "Function function name (argument name As argument type) As return-value type {}"***

Prog11.abs (turtle agent)

```
Agt_Init{
}
Agt_Step{
    if Int(Rnd()*5) == 0 then
        my.DIRX = -1 + Int(Rnd()*3)
        my.DirY = -1 + Int(Rnd()*3)
    end if
    my.X=FixX(my.X+my.DirX)
    my.Y=FixY(my.Y+my.DirY)
}
Function FixX(iX as double) as double{
    Dim LimX as double
    LimX = _GetWidthSpace(World.space)
        If iX > LimX - 1 then
        iX=iX-LimX
    ElseIf iX < 0 then
        iX=iX+LimX
    End If
    Return(iX)
}
Function FixY(iY as double) as double{
    Dim LimY as double
    LimY = _GetHeightSpace(World.space)
        If iY > LimY - 1 then
        iY=iY-LimY
    ElseIf iY < 0 then
        iY=iY+LimY
    End If
    Return(iY)
}
```

Some unfamiliar functions appear in FixX() and FixY(). _GetWidthSpace() and _GetHeightSpace() are functions that obtain the width and height, respectively, of the target space. Using these makes it unnecessary to revise the rule when changing the size of the space.
In order to reduce errors and increase the general utility of rules, you should use function to define constant values, if this value can be changed in its properties dialog box.

> ***"_GetWidthSpace()" returns the width of a space.***

> ***"_GetHeightSpace()" returns the height of a space.***

To apply what you've learned here, rewrite the random placement of agents covered in section 1.5.1, using _GetWidthSpace() and _GetHeightSpace().

1.7 Conclusion

Here is what you've learned in this section.

1.7.1 Terms and Techniques

- How to use World agent rule
- Dim statements
- Loop control (For...Next statement)
- Function
- _CountAgent()
- How to specify hierarchical components
- Agent ID
- Array variable
- _RandomPutAgent()
- Obtaining random integers from 0 to *a*
- Branching with a probability of 1/A
- Spaces that wrap around (loop)
- User-defined function, Function()
- _GetWidthSpace()
- _GetHeightSpace()

1.7.2 Let's Review

- Is it clear what processing is performed in the sample programs?
- Try changing the ranges of the variables in the sample programs, and consider other applications.

1.7.3 Differences in Notation between Visual Basic and *Agent Based Simulator*

The rule format in *Agent Based Simulator* is basically the same as in Microsoft Visual Basic, but there are some difference. These differences are shown below.

Item	*Agent Based Simulator*	Visual Basic
Function definition	`Function {…}` `Sub {…}`	`Function … EndFunction` `Sub … EndSub`
Function return value	`Return(`*return value*`)` ※ Specified as argument of Return function	*Function name = Return value* ※ Input in function name
Variable type declaration	Required	Variant data type when not specified
Comparison operator	`If A==B Then … EndIf` ※ Two "="	`If A=B Then … EndIf` ※ One "="

For … Next	`For i=0 To 10`
	……
	`Next i`
	※ Variable "i" required at end.
		`For i=0 To 10`
		……
		`Next`

Comments	`' …`
	`// …`
	`/* … */`
		`' …`

Special functions	`Agt_Init` : Executed once when created `Agt_Step` : Executed at every step	

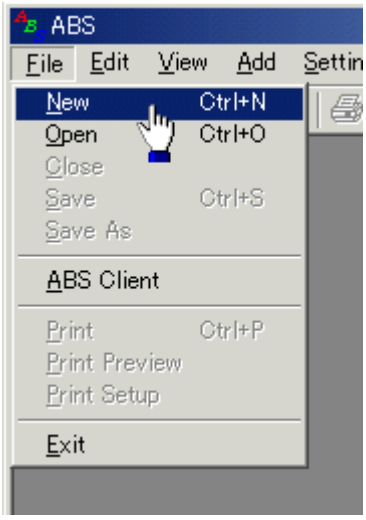
Chapter 2

Reference

2.1 Making Settings for Models

This section describes the features for making model settings, including agents, variables, and other components.

2.1.1 Job File Input and Output



Select one of the commands from the File menu in the following figure to create a new simulation, import an existing job file, or save the settings for a simulation you have created. The setting data for a simulation is saved as a job file (*.abs).

Creating a New Job

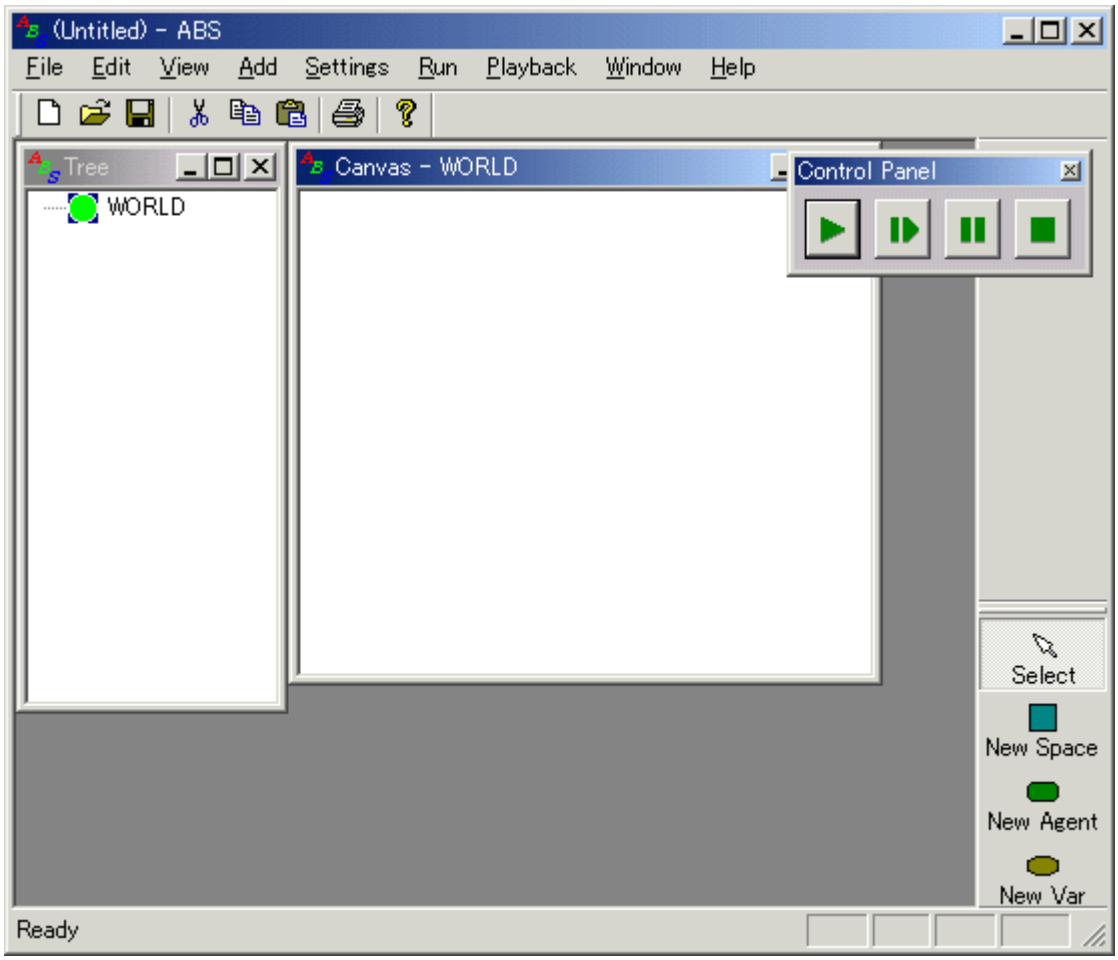
To make settings for a new simulation, from the File menu, select New, or click the New button on the tool bar.

Saving a Job File

To save a job file for which you have made settings, from the File menu, select Save or Save As, or click the Save button on the tool bar.

2.1.2 Creating a New Job File

When you start *Agent Based Simulator* and create a new job file, the following screen appears.



Tree

This is the most basic screen for this simulator. It displays the hierarchical structure of the various components. One agent, the "World agent", always exists in the tree. Create other components such as two-Dimensional space, agents, and variables under it, and make up the settings for the simulation.

Canvas

This is a window that only agents can have. To display it, first select an agent in the Tree window, then go into the View menu and select Canvas, or double-click the agent. You can use this window to place child agents and variables.

Toolbox

You use this when placing child agents, variables, spaces, and the like on the Canvas. Spaces can be placed only on the World agent.

Select

Click this to select or move a component on the Canvas.

New Space

Click this to place a space on the World Canvas.

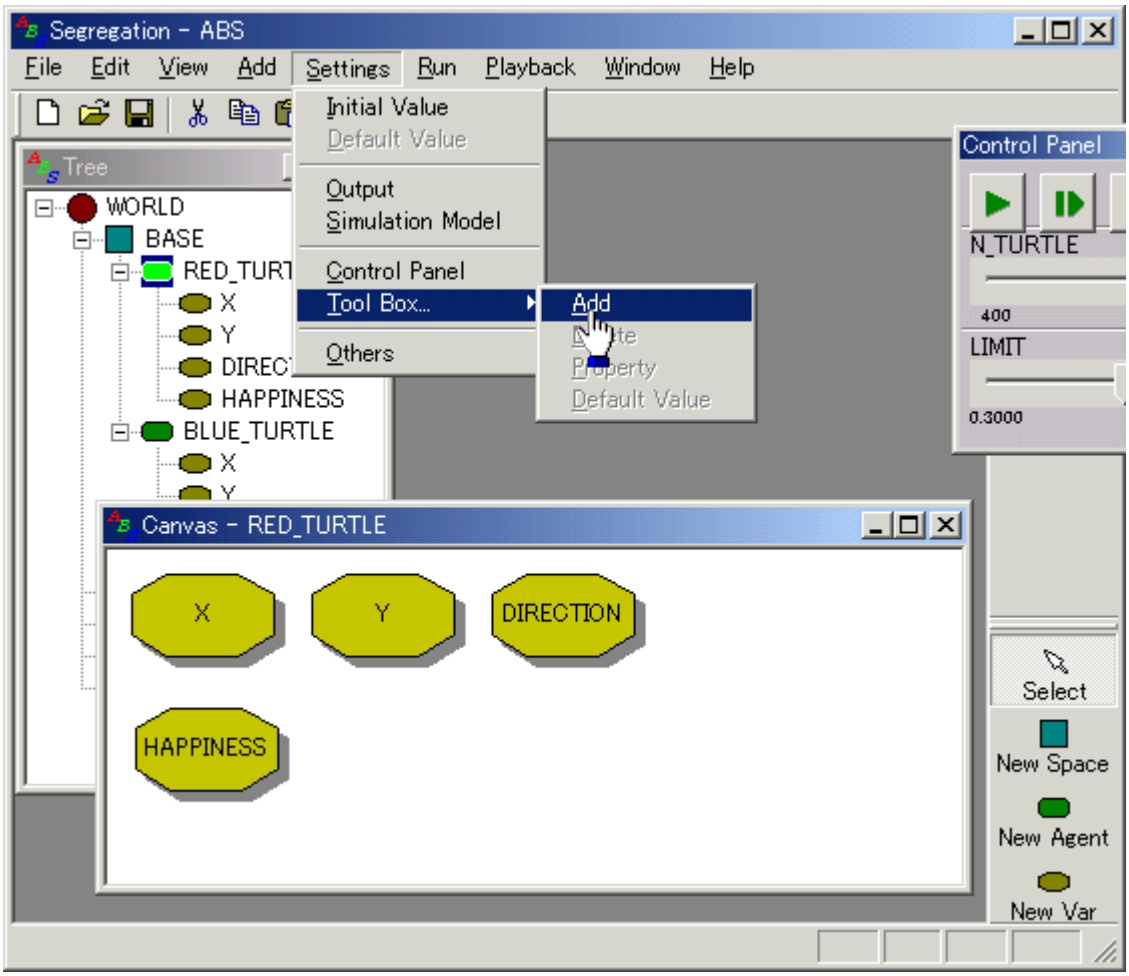
New Agent

Click this to place an agent on the Canvas.

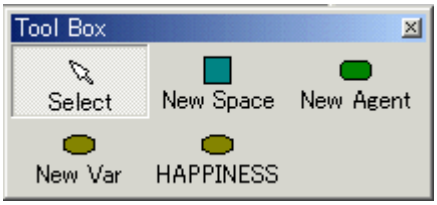
New Variable

Click this to place a variable on the Canvas.

You can also add the components you want to the toolbox. Click the agent or variable on the canvas you want to import, then go into the Settings menu, choose Toolbox, then select Add. The component you selected is added to the toolbox.

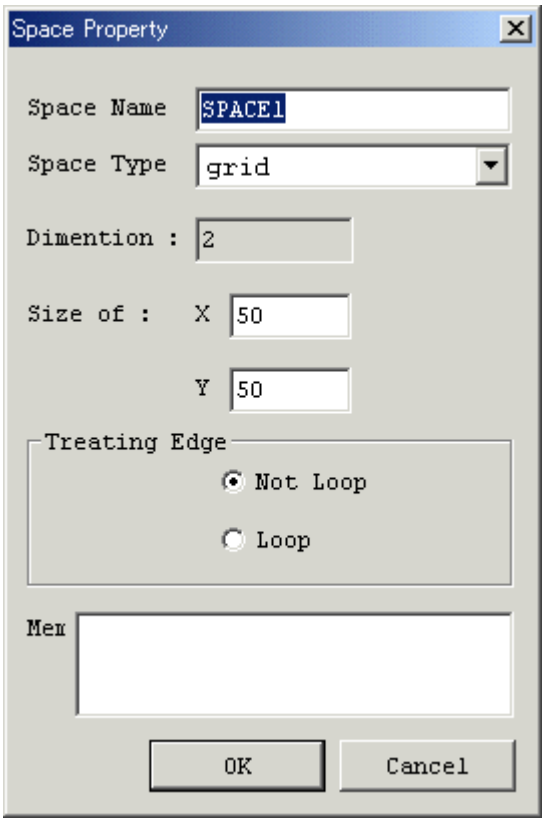


The item you added here keeps the same attributes (initial values, default values, rules, and the like) as the original component.



2.1.3 Creating a New Space

You can create a two-dimensional space for observing the movement of agents on a plane.



1. ***Go to the toolbox and click the Space button. The button should appear to be depressed.***
2. ***Click inside the Canvas – World window.***
3. ***The following Space Properties dialog box appears.***

Space Name

Enter the space name you want. The default is "SPACE_1".

Space Type

Choose the type of space. Select either the grid model or the hexagon model.

Number of Space Dimensions

Because this is a space, the setting is "2", indicating two dimensions.

Space Size

This sets the size of the space, with one site for one agent or variable. The default size is 50 × 50.

Edge of Space

When you select the Loop check box, a component that reaches the edge of the space appears again on the opposite side. When you select Do Not Loop, components bounce back.

Note

You can any text you want, up to a length of 256 characters. What you enter here has no effect on the simulation, so you can use this area for making notes.

4. ***Click OK to close the dialog box. A space appears on the canvas.***

Now you've established a space immediately under the World agent.

Important : You can only create a space immediately under the World agent. ABS is designed that way to keep things conceptually easy to understand.

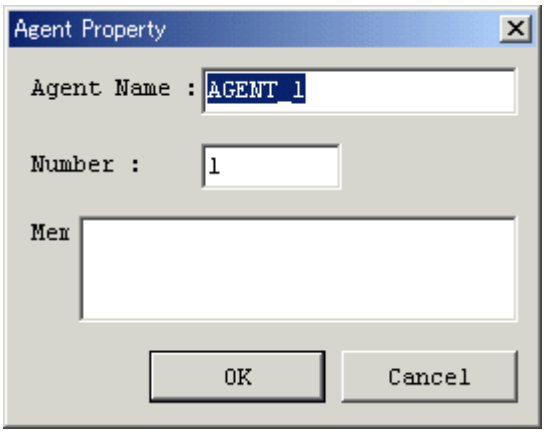
2.1.4 Creating a New Agent

This section describes how to create a new agent in a space. Unlike space, agents can be created immediately under the World agent or other agents. The example here shows how to create an agent in a space.

1. ***Open "Canvas – space name". Here, space name is "SPACE_1".***

   You can use any of several techniques to open the canvas.
   - Double-click a component in the tree or on the canvas.
   - Right-click a component in the tree or on the canvas, then select Canvas from the menu.
   - Select a component in the tree or on the canvas, then choose Canvas from the View menu.

2. ***Click the Agent button in the toolbox. The button should appear to be depressed.***
3. ***Click anywhere inside the Canvas – SPACE_1 window.***
4. ***The following Agent Properties dialog box appears.***



Agent Name

Enter the agent name you want.

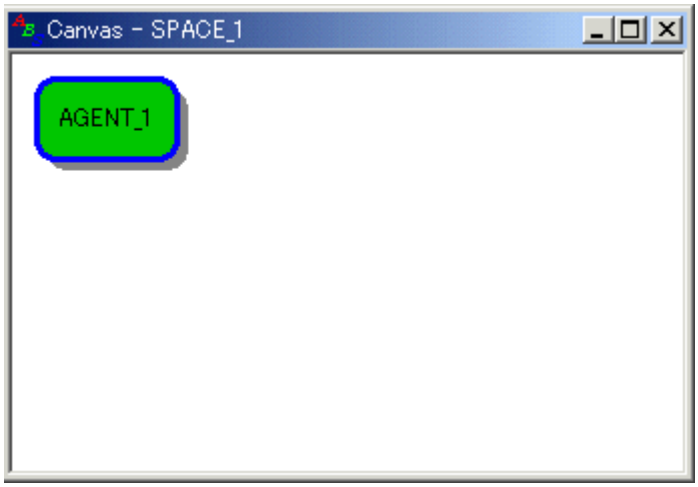
Number of Agents

Enter the number of instances of this agent. The number you enter here is used to create instances of agents acting according to the same rules. In other words, this is the number of copies of identical agents.

Note

You can any text you want, up to a length of 256 characters. What you enter here has no effect on the simulation, so you can use this area for making notes.

5. Click OK to close the dialog box. The agent appear on the canvas.



Now you have created a new agent immediately under the space. You use the same procedure to create a new agent immediately under the World agent or another agent.

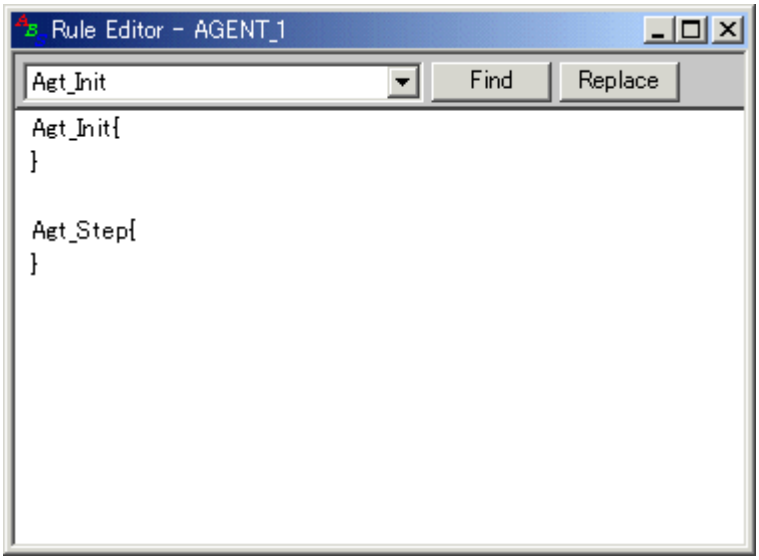
Important : When you put an agent in a space, the three variables X, Y, and Direction are automatically placed under the agent. These variables contain the coordinate information for the agent.

2.1.5 Writing the Agent Rules

After you create an agent, it doesn't do anything without rules for it. You need to write agent rules for each agent.

1. Choose an agent and open the Rule window.

There are three types of Rule windows; the World Rule Editor for writing rules for the World agent, the Agent Rule Editor for writing rules for other agents, and the Common Rule Editor which can be referenced from anywhere.
To open the Rule Editor, select an agent, then go into the View menu and choose Rule Editor or Common Rule Editor. Alternatively, right-click the agent, then select Rule Editor.
When you do this, the following window appears.



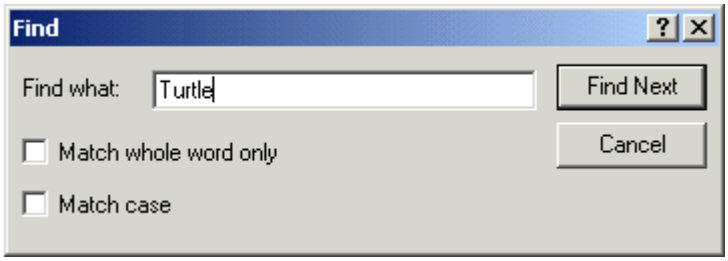
2. ***Write the agent rules inside this window.***

   For "Agt_Init{}", write, between the "{" and "}", the rules that are to be executed only once, when the agent is created.
   For "Agt_Step{}", write, between the "{" and "}", the rules that are to be executed at every step of the simulation.

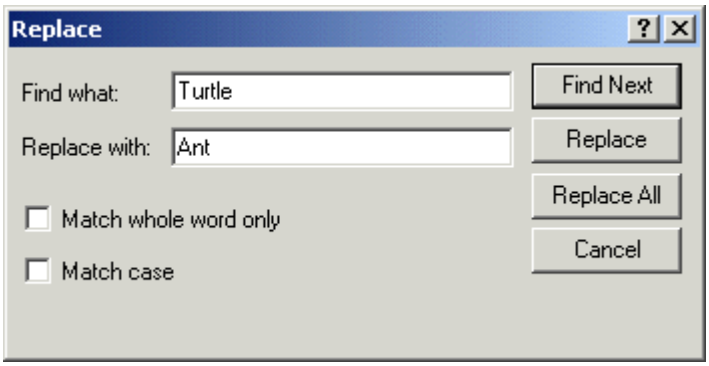
Search and Replace Features

While the Rule Editor is open, go into the Edit menu and select Find or Replace to display the Find or Replace dialog box.

(1) Find screen



(2) Replace screen



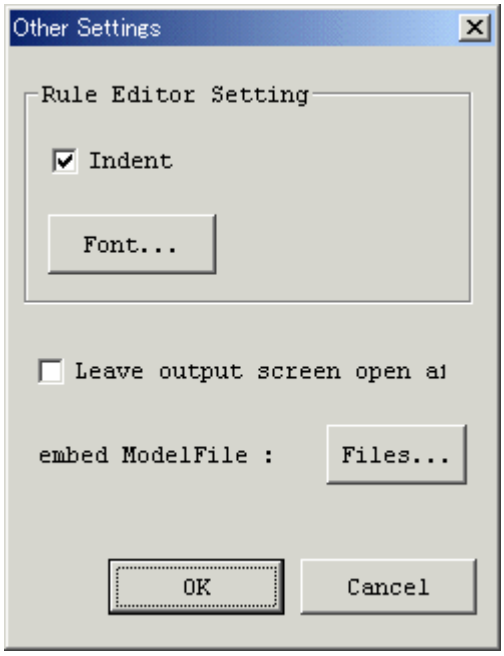
Important : Existing multi-agent simulators have had a serious drawback; simulations cannot be constructed unless the user masters an extremely difficult programming technique. The development of Agent Based Simulator addressed this point. However in order to

enable you to construct simulations and make settings for rules as freely as possible, the writing of programmatical rules is kept to the minimum necessary. To learn more about rules, study rules such as those in the sample models.

The format of the rules used in *Agent Based Simulator* is based on the syntax of Microsoft Visual Basic, which is relatively easy to learn. For information about the required syntax, see "Chapter 3 — Agent Rule Syntax".

Rule Editor Settings

You can set the font for the Rule Editor by going into the Settings menu and selecting Other Settings.

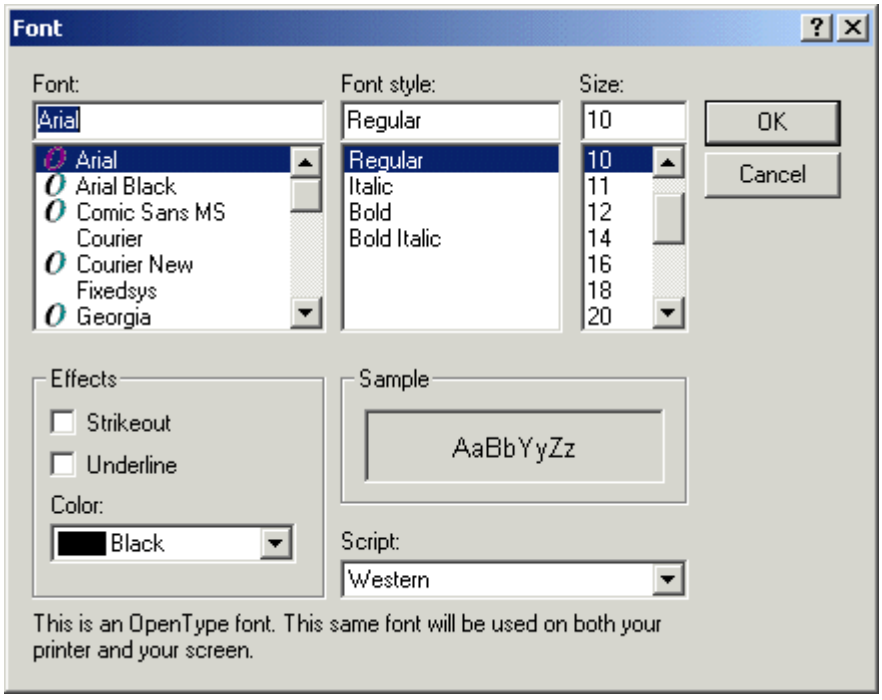


Automatic Indent

When this check box is selected, automatic indenting is performed for rules you write in the Rule Editor.

Set Font

Clicking Set Font displays the Font dialog box.



Keep Output Screen After Running

When you clear this check box, the output screen is deleted when the simulation ends.

Import Model Description File (Select File button)

You can embed a file describing the model in the job file. The embedded file must be in HTML and images are not permitted. You can view the embedded model-description file at any time by going into the Help menu and selecting Model Description. For more information, see section 2.5.

The Rule Editor view is immediately updated with the settings for font, style, size that you make here.

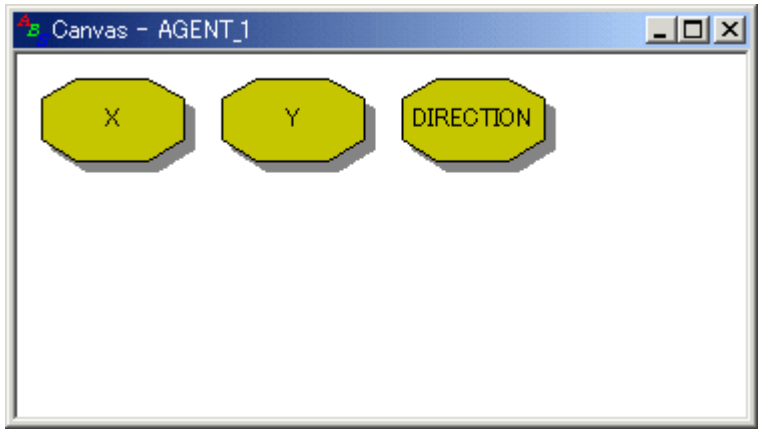
2.1.6 Deleting an Agent

Click the agent you want to delete, then from the Edit menu, select Delete. Alternatively, right-click the agent, then from the menu, select Delete.

2.1.7 Creating a New Variable

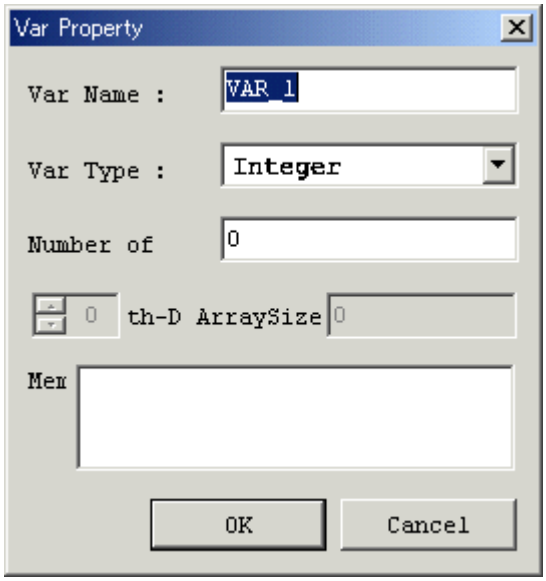
This creates a new variable for an agent. You can create a variable under any agent.

1. ***Open "Canvas – agent name". Here, agent name is "AGENT_1. The following window appears.***

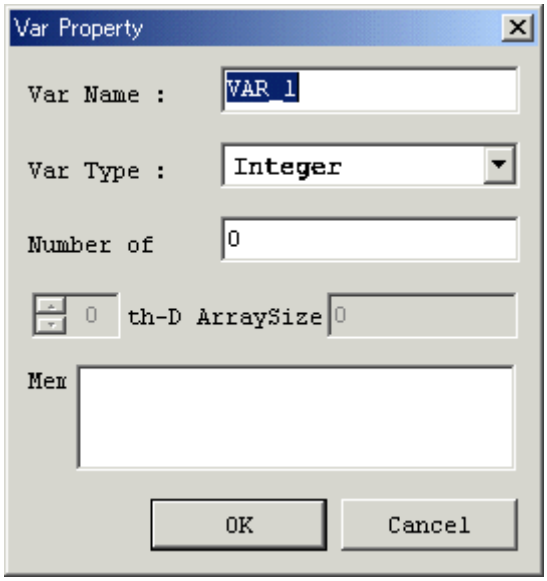


Important : If you have created an agent in the space, variables named X, Y, and Direction are already created. These variables indicate the agent's coordinates in the space. When no space exists, they are not created.

2. ***Go to the toolbox and click the Variable button. The button should appear to be depressed.***
3. ***Click the blank area in the "Canvas – AGENT_1" window.***


Var Property
Var Name :
VAR_1
Var Type :
Integer
Number of
0
0
th-D ArraySize
0
Mem
OK
Cancel

4. A Variable Properties dialog box appears.



Type	Name	Value range
Boolean data type	Boolean	True or False.
String data type	String	0 to 1,000 characters
Integer data type	Integer	from –2,147,483,648 to 2,147,483,647
Real data type	Double	from -1.79769313486232×10^{308} to 4.94065645841247×10^{324} (when negative) from 4.94065645841247×10^{324} to 1.79769313486232×10^{308} (when positive)
Object data type	Object	Agent entity value
Collection data type	Collection	Array of variables of Object data type

Basically, you should choose String data type for text, Integer data type for integers, and Double data type for numbers that include a fractional portion. Boolean data type is a little special — it has a value of either Yes (True) or No (False). Object data type is used when you want to employ an object itself in an argument for a function. Collection data type is used for a set of such objects.

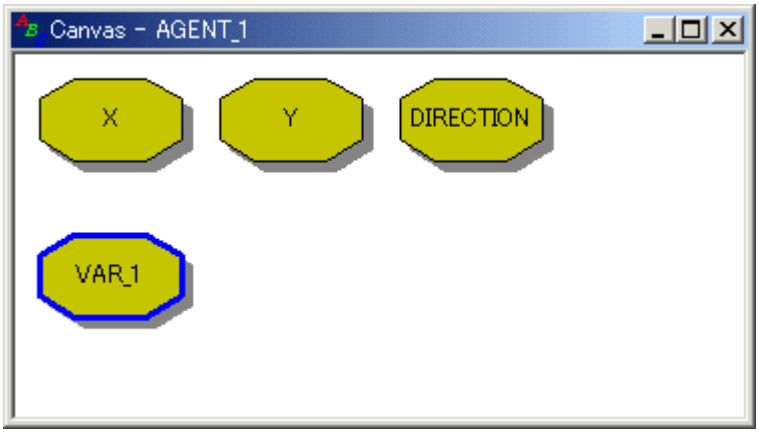
Number of Dimensions

A variable is like a container for holding data. In principle, a single variable can hold only one item of data. When a variable is newly created, it has zero dimensions (that is, it's a point on a plane), therefore it stores a single data item. However, that's not convenient for handling large amounts of data of the same type, so by increasing the number of dimensions, you can also increase the number of data items that can be stored. Incidentally, in the case of a single-dimension variable, the variable can store $n+1$ items of data, counting from zero to the array size n. In the case of two dimensions, when the array size is m for first dimension and n for second dimension, the variable can store $(m+1) \times (n+1)$ items of data. This is indicated as "variable (m, n)". The array size starts at zero, so be careful to add one to the quantity.

Note

You can any text you want, up to a length of 256 characters. What you enter here has no effect on the simulation, so you can use this area for making notes.

5. Click OK to close the dialog box. A variable appear on the canvas.



Now you've created the new variable "VAR_1" under an agent. You use the same procedure to create a new one immediately under the World agent or a space.

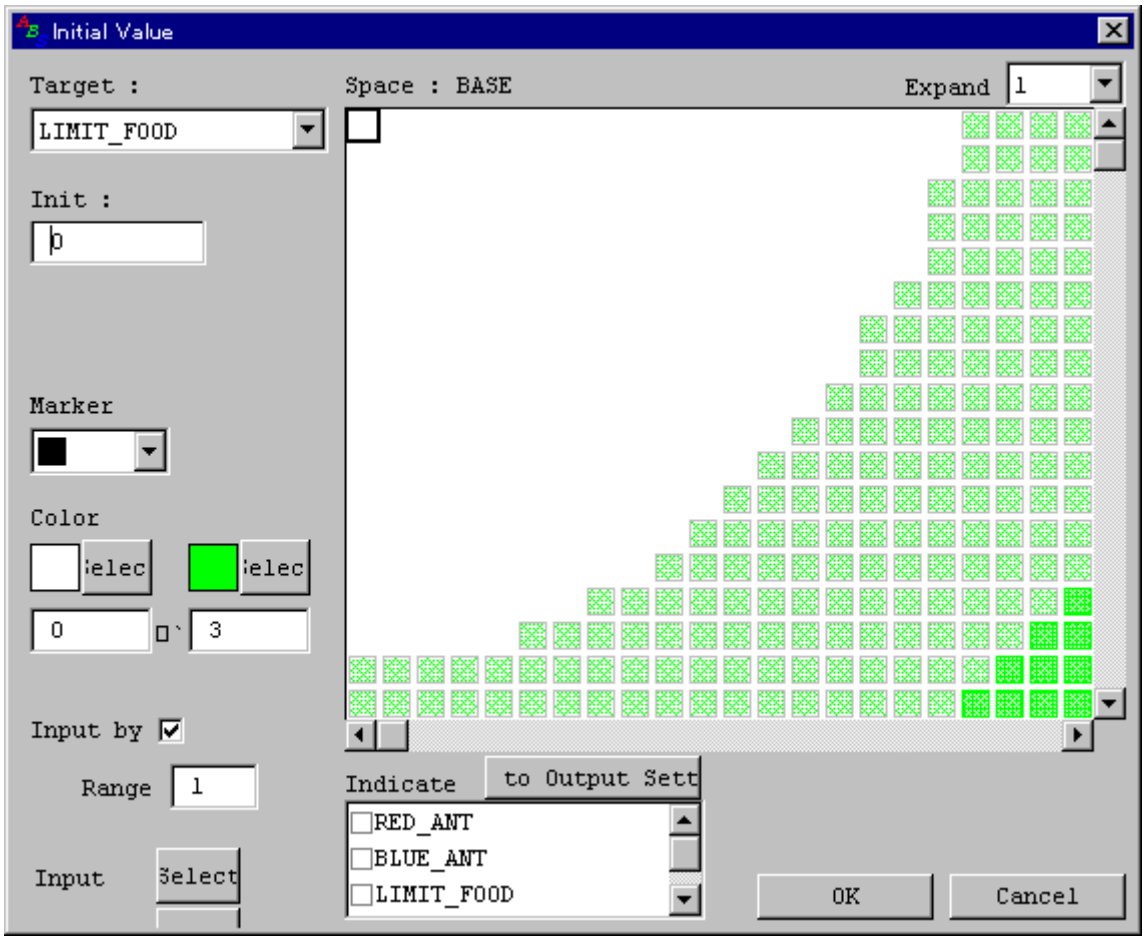
2.2 Simulation Setting Feature

2.2.1 Initialize Dialog Box

This is for setting the initial values for components.

To display the Initialize dialog box, select the components in the Tree, then go into the Settings menu and choose Initialize. The screen for setting the initial values varies according to the type of component.

Initialize Dialog Box for Two-dimensional Space



This dialog box appears when you go to the Tree window, select Two-dimensional Space, then go into the Settings menu and choose Initialize. You place agents and variables by clicking any coordinates in "Space: Two-dimensional Space".

important : When you display this dialog box, in the initial state all the agents may be bunched together in the upper-left corner. If this happens, click the Clear Screen button to reset the screen. Doing this eliminates the placed agents.

Make sure the agents are gone from the space, then click where you want to place the agents. In order to place multiple agents at one location, enter the numerical value in Range of Change.

Setting Target

Select the agent or variable to be placed on the two-dimensional space.

Number of Agents

This sets the number of agents to be placed at the point you select by clicking with the mouse. If you have chosen Select with Mouse (described later), then the numerical value set for Range of Change is automatically entered.
If you have chosen a variable for Setting Target, this field changes to Initial Value.

Total Number of Agents
Maximum Number

The value set for Number of Agents in Properties automatically appears in the Maximum Number field, and the present number of placed agents automatically appears in the Total Number of Agents field.
If you have chosen a variable for Setting Target, these do not appear.

Marker
Color

These set the type and color of the markers indicating agents and variables in the two-dimensional space.

Select with Mouse

When you select this check box, then each time you click the coordinate, the number of components increases or decreases by the amount set for Range of Change.

File Input
File Output

You can import the initial values from an existing file or save them in a file by clicking these buttons.

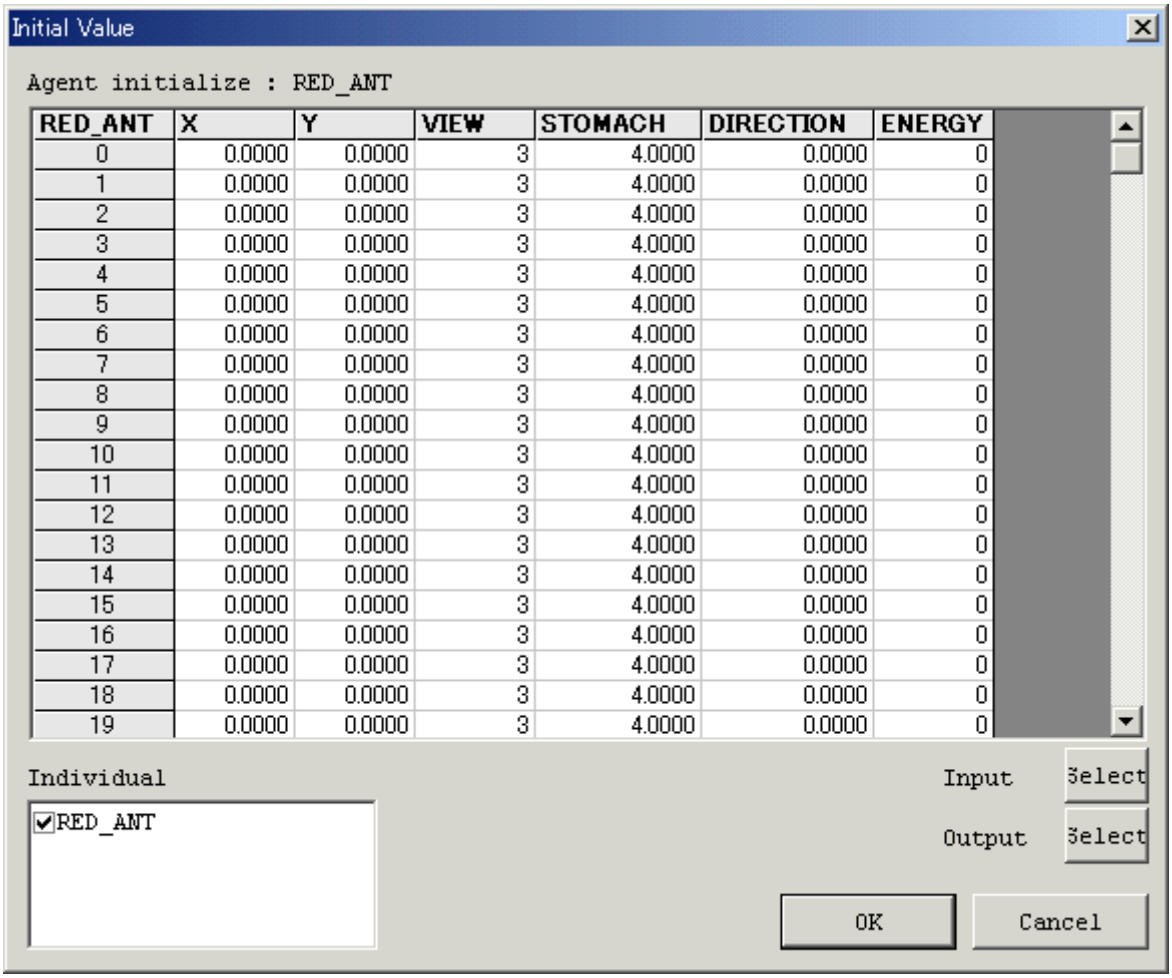
Display List

Selected components appears on "Space: Two-dimensional Space".

Initialize Dialog Box for Agents and Variables

You can set the initial values of agents and variables that are used when the simulation starts.

To display this dialog box, select an agent or a variable in Tree window, then go into the Settings menu and choose Initialize.



Target Agent: Red Ant

This indicates that current setting target is the initial value of the agent named Red Ant. When you have selected a variable, this field changes to "Agent Variable Initialize: *variable name*". Enter the numerical values you want to set in the table under this.

Individually Set Agents

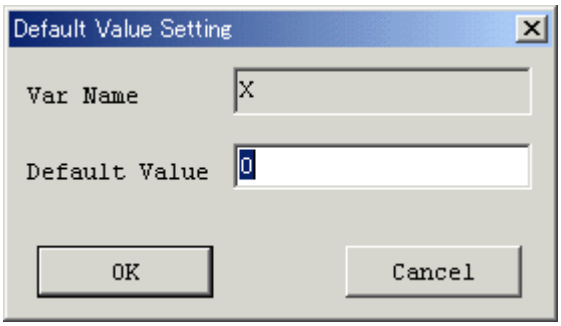
When setting for multiple agents, you can set the values individually for each by selecting the corresponding check boxes.

File Input

File Output

You can import the initial values from an existing file or save them in a file by clicking these buttons.

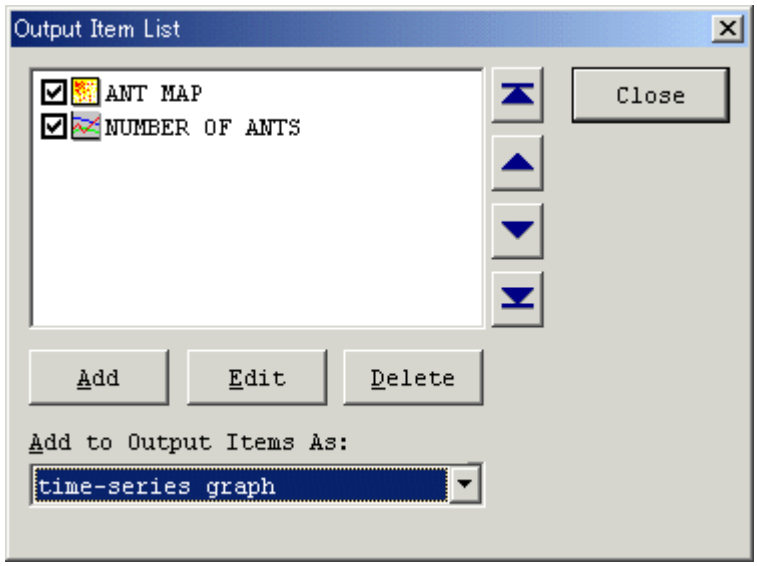
2.2.2 Set Default Dialog Box



To set the default values for vari ables by going into the Settings menu and choosing Defaults.

Ordinarily variables are assigned initial values, but if a variable is added by an agent rule (with _CreateAgent, for example), then the numerical value of this default is stored in the added variable.

2.2.3 Output Settings Dialog Box



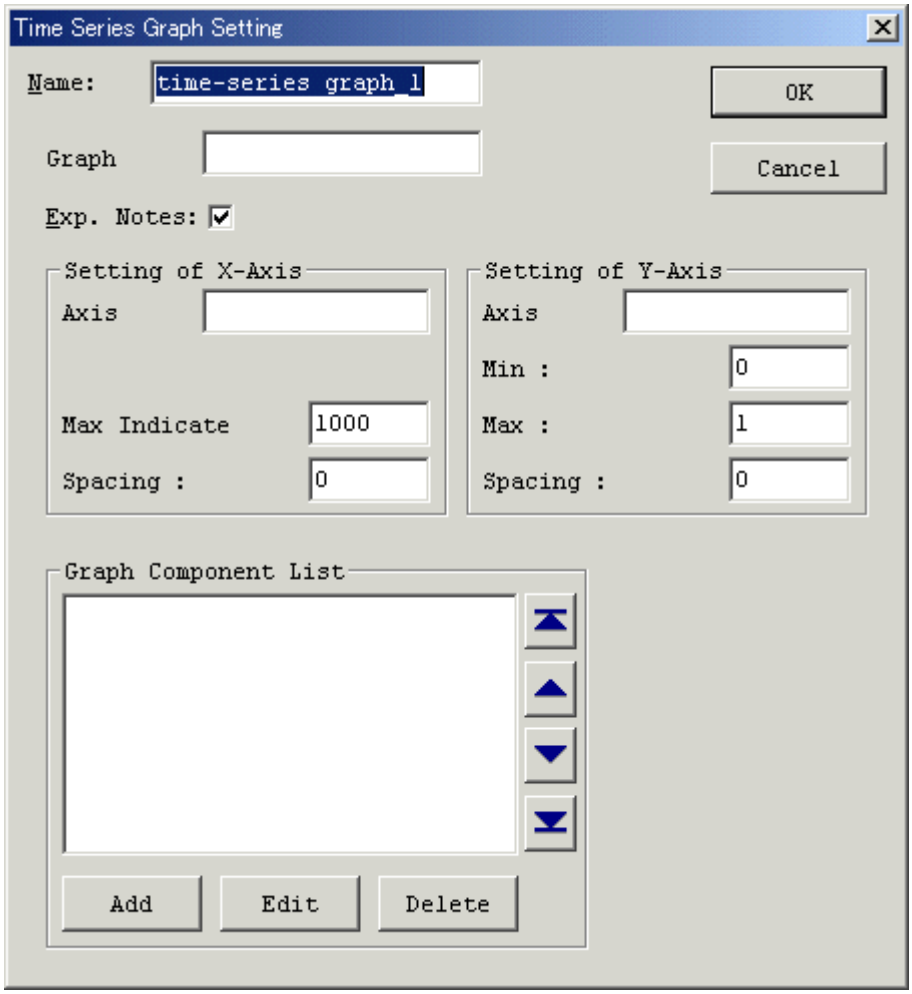
The Output Item List dialog box appears when you go into the Settings menu and choose Output.

To make the settings for graph and file output methods, go into Output Type to Add in this dialog box, choose a graph or file, then click Add.

If multiple outputs are required, you need to add the output methods. The series of Output Items settings change to Move Icons. To change visible/unvisible selects to View check box.

Time-series Graph Output Settings

Time-series graph displays components as a time-series line. To make settings this graph, select Time-series Graph in Output Type to Add field.



Name

This is the name referenced when calling up this graph.

Title

This title appears on the graph displayed on the output screen.

Show Legend

When you select this check box, a legend is displayed next to the graph.

Axis Label

When the graph is displayed, this item is also displayed as the label for the axis.

Minimum Value
Maximum Value
Scale Interval

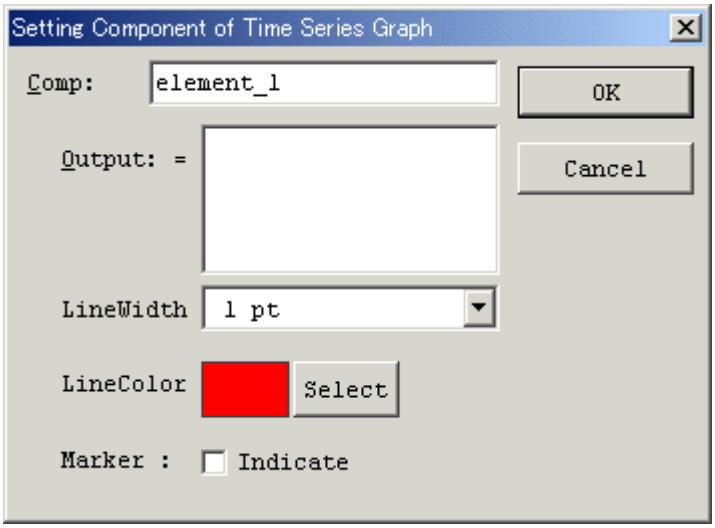
These specify the minimum value, the maximum value, and the interval of the scale for the displayed graph.

Maximum Number of Displayed Steps

With each step, the time-series graph is displayed in a compressed form. When you set the number of steps here, a portion of the graph corresponding to the set number of steps is always displayed. That is, older data sequentially disappears from the left side.

Graph Component List

Clicking Add displays another dialog box for setting.



Component Name

In this field, you can give this graph component a name of your choosing.

Output Value

Enter the names of the graph components (such as variables) whose histories you want to view.

Line Width

Line Color

These set the width and color of the lines in the graph.

Marker

When you select this check box, markers are displayed on the graph.

If you want to display multiple graphs on the screen at the same time, you need to add each of their components (such as agent 1, agent 2, variable 1, and so on) as graph components. In other words, the corresponding number of elements must be arranged in the list.

You can select and edit existing graph components by clicking Edit. You can also select and delete existing graph components by clicking Delete. At Output Value in Graph Component List, a numeric to surrounded by "@" is unfolded.

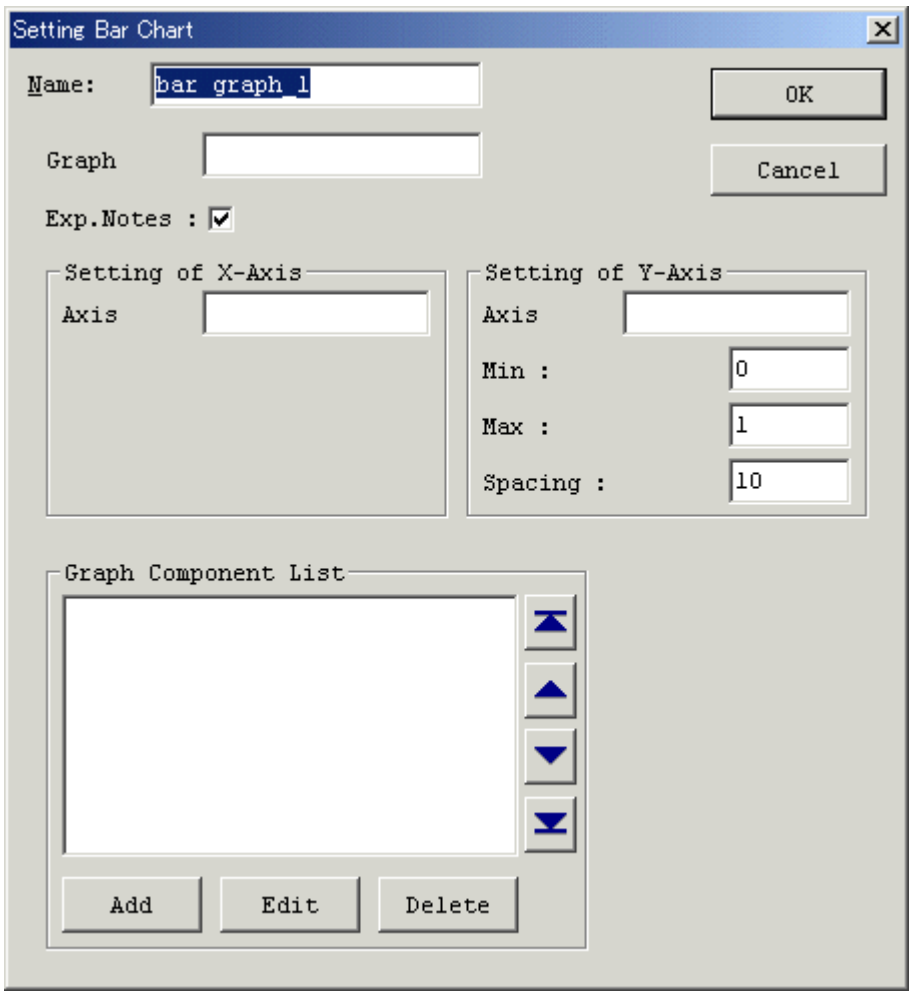
example:
"World.Val(@3,5@)" writes

World.Val(3)
World.Val(4)
World.Val(5)

Bar Graph Output Settings

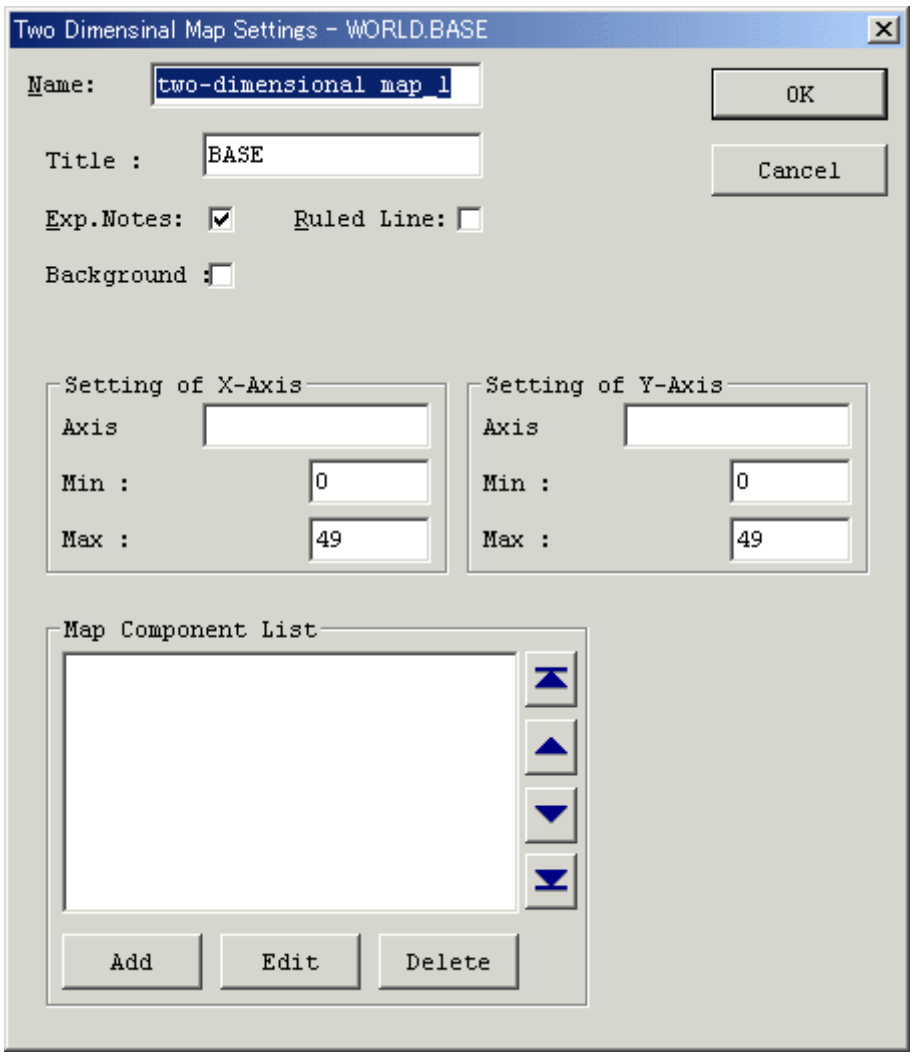
This output method displays components as a bar graph. When you select this with Output Type to Add, the following dialog box appears.

Almost all the setting items are the same as for time-series graphs.



Two-dimensional View Map Output Settings

This output method arranges agents and variables on a two-dimensional view map to show their movement, increase, and decrease. When you select this with Output Type to Add, the following dialog box appears.



Show Gridlines

When you select this check box, horizontal and vertical gridlines are drawn on the two-dimensional map.

Show Backgroud Graphics

When you select this check box, a backgroud graphics is displayed on two-dimensional space.

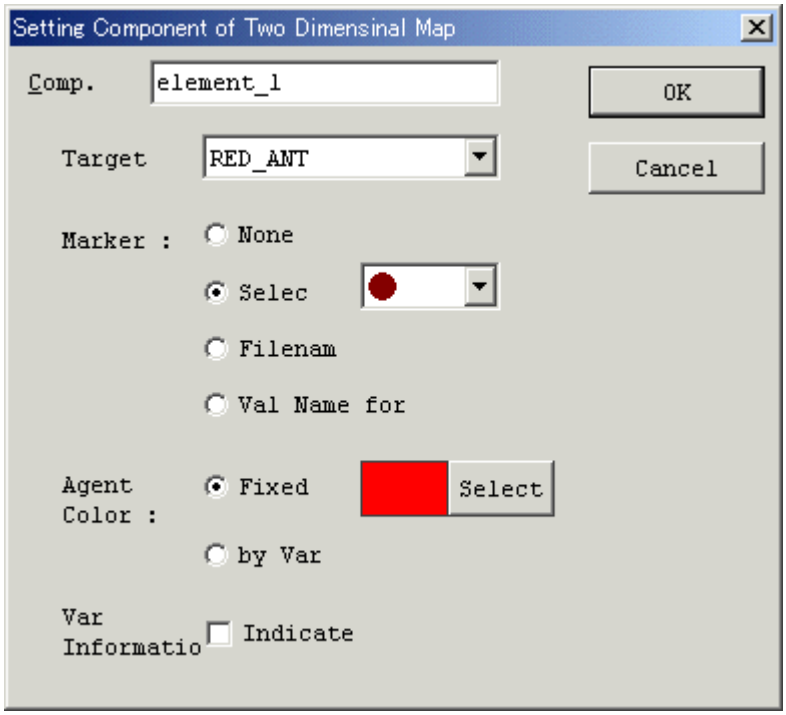
X-axis Settings

Y-axis Settings

It's possible to display only specific portions on the map by making settings for the minimum and maximum values. The initial maximum values are assigned the space size.

Map Component List – Add

Clicking the Add button for Map Component List displays another dialog box for setting.



Component Name

In this field, you can give this graph component a name of your choosing.

Output Target

Select the components (agents and the like) whose movement you want to view on the map.

Marker

This selects how markers are displayed for components on the map. When you select None, markers are not displayed. When you choose Select, you can select out of circle, triangle, square, or ×. When you select File Name, you can replace the marker with an image of your choosing by entering the path to an image file (at present only icon files are supported). When you choose Variable Name Specifying File, you can select a variable in World.

Agent Color

You select either Fixed Color, which specifies a single color of your choosing, or Variable-dependent, which makes the color change dynamically according to the value of the variable.

Agent Variable Information

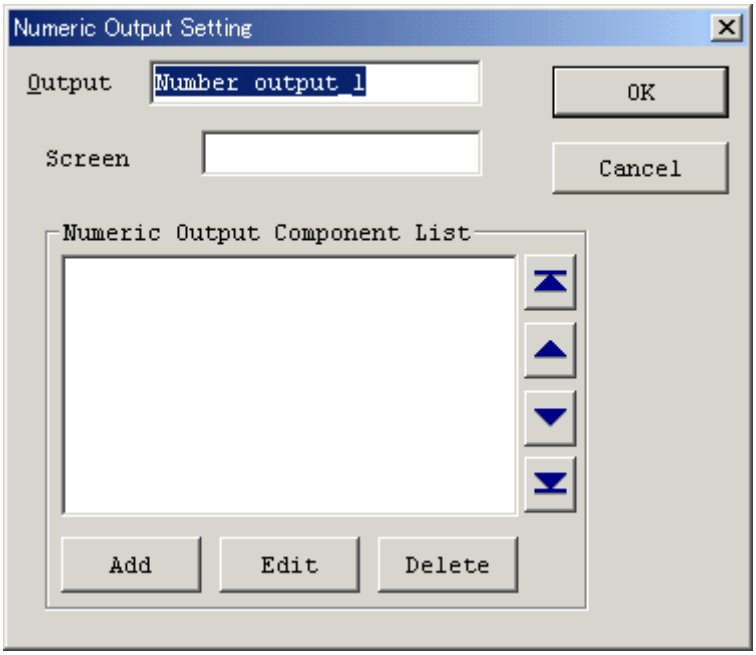
When you select the check box for Show Information, the values of specified variables appear above the agents on the map.

If you want to display multiple components on the screen at the same time, you need to add each of their components (such as agent 1, agent 2, variable 1, and so on) as map components. In other words, the corresponding number of elements must be arranged in the list.

You can select and edit existing map components by clicking Edit. You can also select and delete existing map components by clicking Delete.

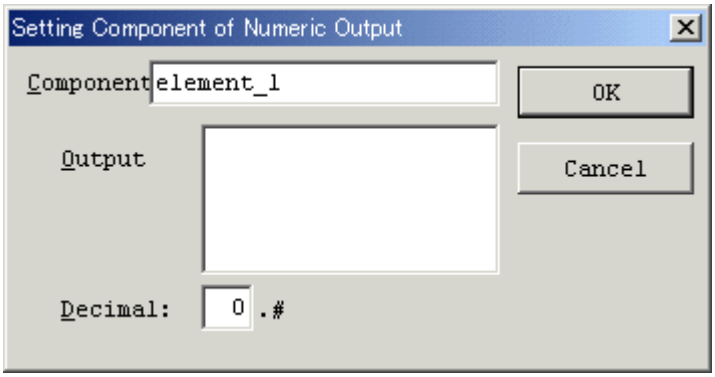
Numerical Screen Output Settings

This output method displays components as numerical values. When you select this with Output Type to Add, this dialog box appears.



Numerical Screen Output Component List – Add

Clicking the Add button for Numerical Screen Output Component List displays this screen.



Component Name

In this field, you can give the numerical screen output component a name of your choosing.

Output Value

Enter the variable or computational expression you want to output.

Show Fractional Numbers

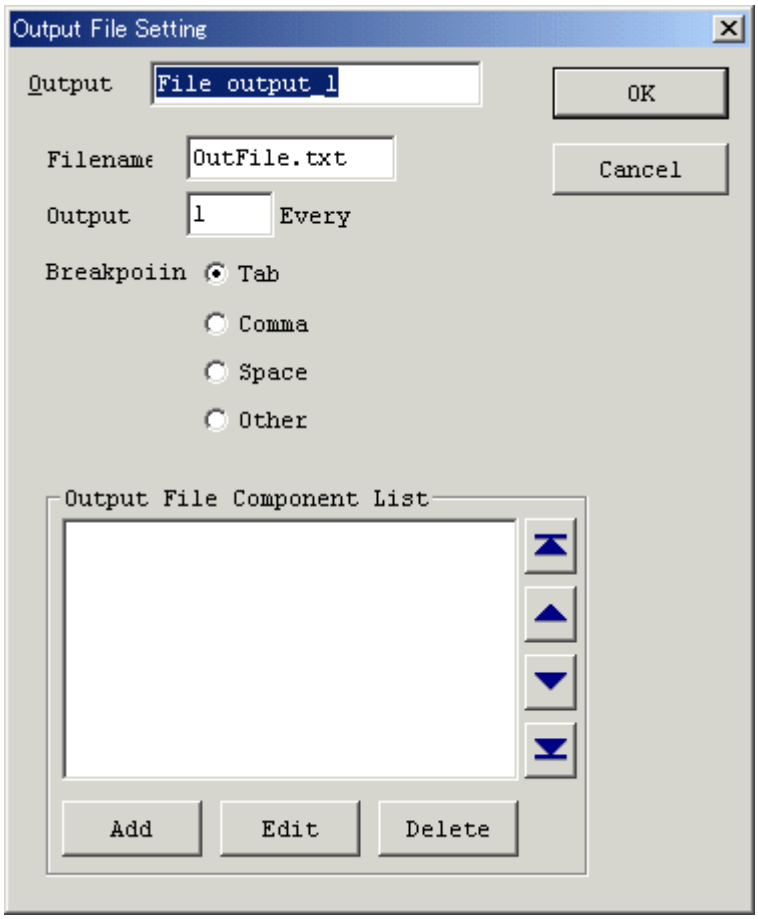
This setting determines how many digits to the right of the decimal point are displayed.

If you want to display multiple components on the screen at the same time, you need to add each of the components (such as agent 1, agent 2, variable 1, and so on) as numerical screen output components. In other words, the corresponding number of elements must be arranged in the list.

You can select and edit existing numerical screen output components by clicking Edit. You can also select and delete existing numerical screen output components by clicking Delete.

File Output Settings

File output saves a log of the simulation to a file. When you select this with Output Type to Add, the following dialog box appears.



Output Name

This is the name references when this file output is called.

File Name

This is the file name for output. The default is OutFile.out. To change the file name, click Settings and change the setting.

Output Interval

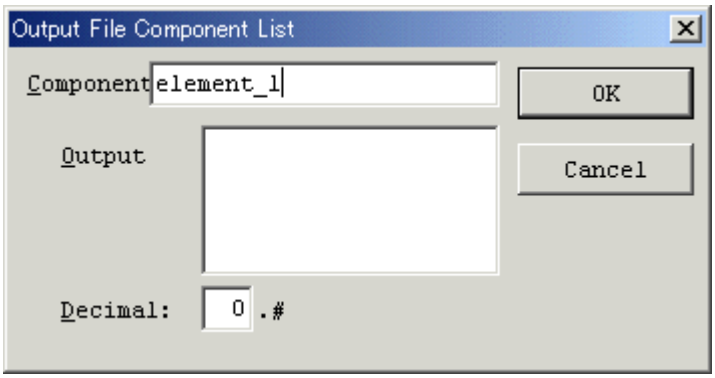
This sets the timing for output to the file.

Separator

This selects the separator character for output data.

File Output Component List – Add

Clicking the Add button for File Output Component List displays this screen.



Component Name

In this field you can give the file output component a name of your choosing.

Output Value

Enter the variable you want to output.

Show Fractional Numbers

This setting determines how many digits to the right of the decimal point are displayed.

If you want to output multiple data items to the output file at the same time, you need to add each of the components (such as agent 1, agent 2, variable 1, and so on) as file output components. In other words, the corresponding number of elements must be arranged in the list.

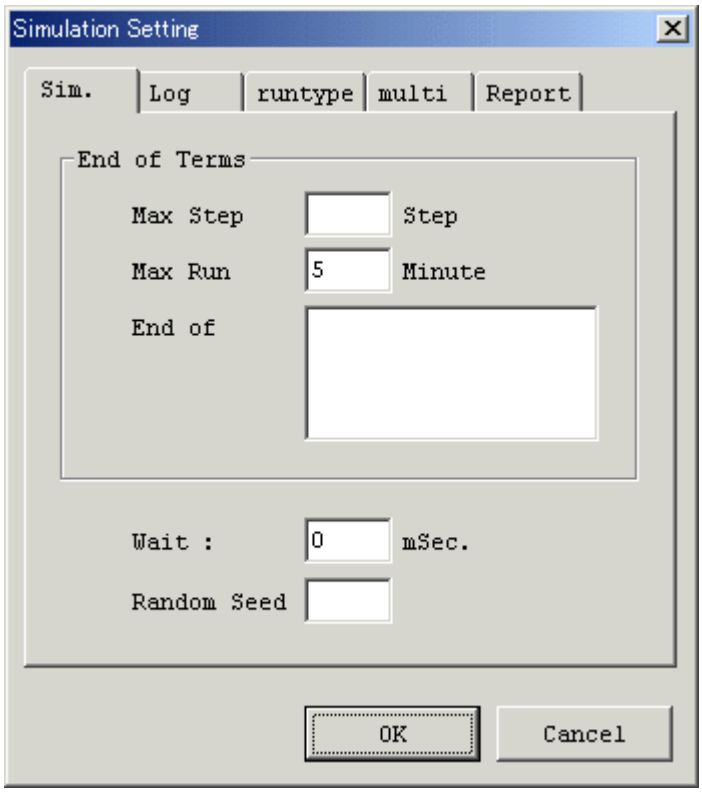
You can select and edit existing file output components by clicking Edit. You can also select and delete existing file output components by clicking Delete.

2.2.4 Execution Environment Settings Dialog Box

Here is where you make various settings for running simulations.

From the Settings menu, choose Execution Environment Settings. The Execution Environment Settings dialog box appears. This dialog box has five tabs; Simulation, Log File, Run Sequence, Run Continuously, and Report Output. You can move among these tabs to make the settings.

Simulation Tab



Maximum Number of Steps

The number of steps specified by this value is executed, unless you quit the simulation partway through.

Maximum Execution Time

Steps are executed until the time specified by this value elapses, unless you quit the simulation partway through.

Ending Conditional Expression

Steps are executed until the conditional expression entered here is fulfilled, unless you quit the simulation partway through.

Execution Pause Time

When one step ends, processing pauses for the time specified by this value. If you are using a fast computer and the simulation speed is too rapid, then enter a suitable value here.

Random Number Seed

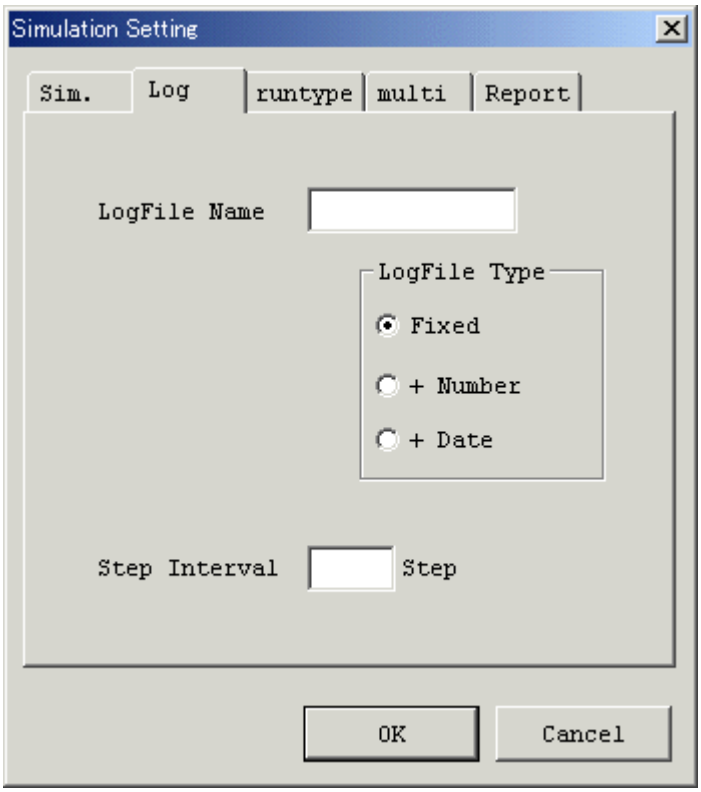
You can specify a pattern for random numbers.

Log File Tab

Log File Name

Log File Name Format

These set the name of the log-file. Clicking Set displays a dialog box for saving, where you can specify a file name and location of the log file.



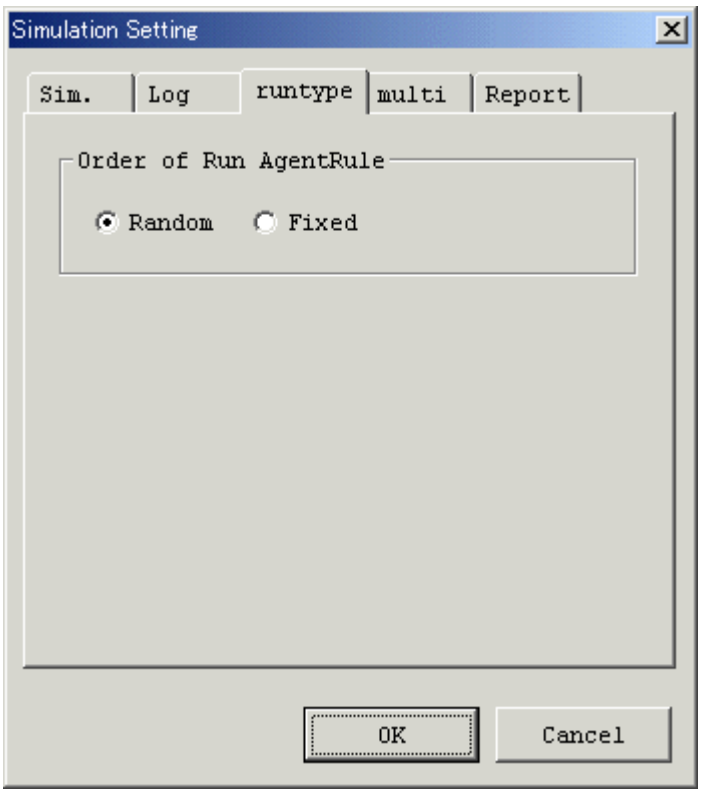
Logging Step Interval

When you enter a value here, logging to the log file is performed during execution of the simulation. When the entered value is 1, logging is performed at every step. A log file having the name of your choosing (***.abs) is created. You can play back the executed simulation by opening this file.

Run Sequence tab

Agent Rule Run Sequence

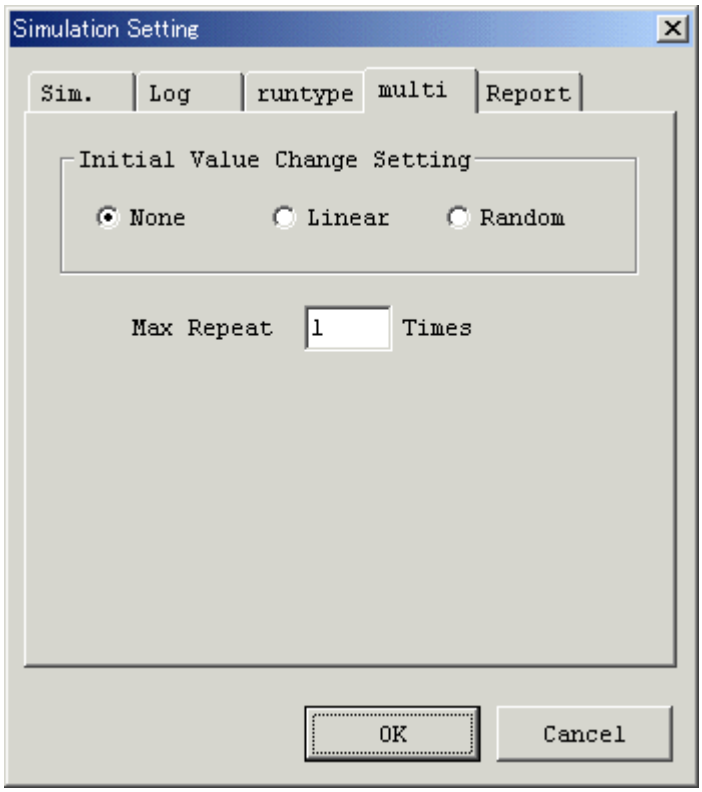
Agt_Step for World is executed first in the step, but you can use this screen to change the settings for Agt_Step for agents. When you select Random, the execution sequence for agent rules is determined randomly. When you select Fixed Sequence, execution proceeds in sequence, from the top of the tree down.



- ***When Initial Values Change Setting Is Set to None***

Maximum Number of Executions

The simulation is repeated the number of times entered, unless you quit the simulation.

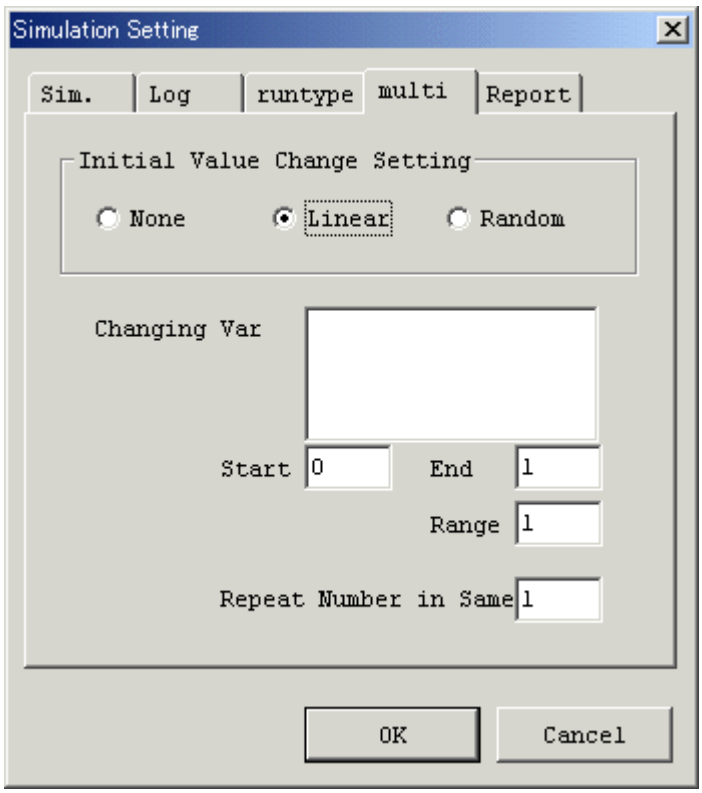


- ***When Initial Values Change Setting is Set to Linear***

Initial Value Change Variable Name

When you want to perform a simulation with the initial value of a particular variable changed in a stepwise manner, then enter the variable name here.

For instance, if you want to execute a total of 11 types of simulations with the initial value of a particular variable varied from 0 to 1 in steps of 0.1, ordinarily you would have to redo the setting of the initial value ten times and run a simulation for each one. By using this setting, however, you can make the setting once and perform simulations while varying the initial value automatically until the conditions are fulfilled.



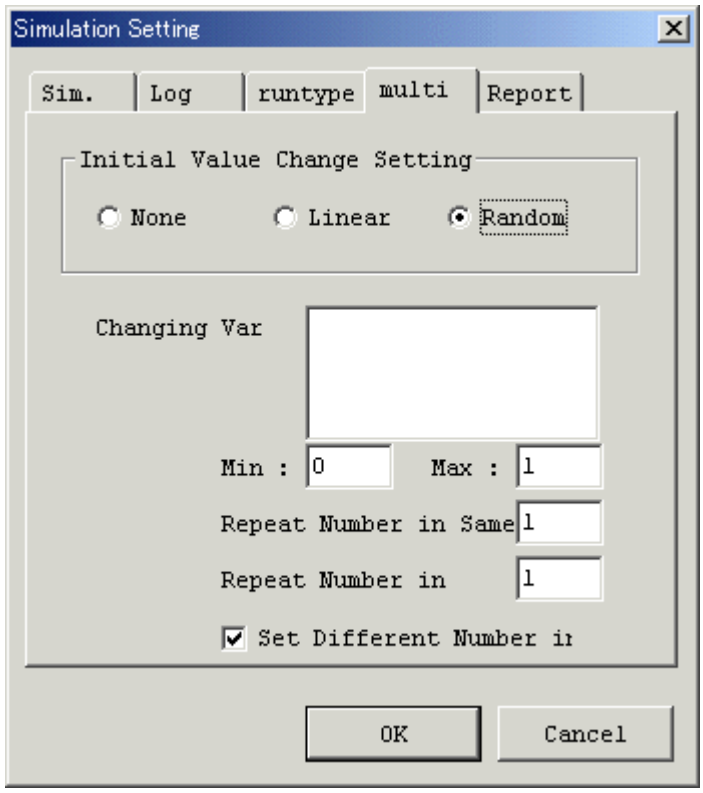
Start Value
End Value
Range of Change

These set the start value, end value, and range of change for the variable to be changed.

Number of Executions with Same Initial Value

This sets the number of times to execute the same simulation before changing the initial value.

- ***When Initial Values Change Setting Is Set to Random***



Initial Value Change Variable Name

When you want to perform a simulation with the initial value of a particular variable changed randomly, then enter the variable name here. For instance, if you want to execute a total of 10 types of simulations with random numbers in the range of 0 to 1 used as the initial value of a particular variable, ordinarily you would have to redo the setting of the initial value ten times and run a simulation for each one. By using this setting, however, you can make the setting once and perform simulations while varying the initial value automatically until the conditions are fulfilled.

Minimum Value
Maximum Value

These set the minimum and maximum values of the range of random numbers for the variable to be changed.

Number of Executions with Same Initial Value

This sets the number of times to execute the same simulation before changing the initial value.

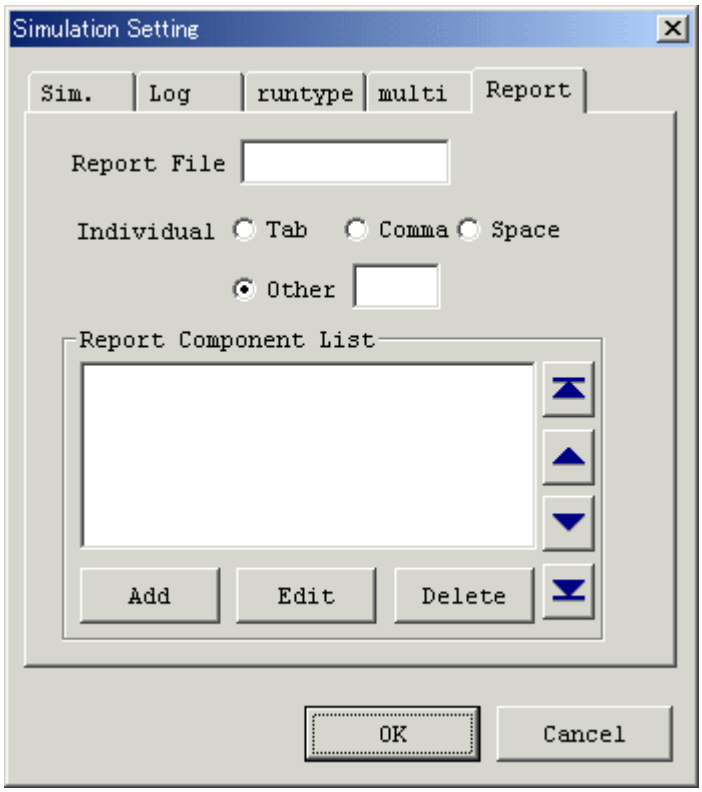
Number of Executions with Different Initial Value

This sets the number of times to execute the simulation with the initial value varied randomly.

Set Different Values for Same level Variables

Select this check box when you want to apply the different random number to identical variables of the same agent (for example, turtle(0), turtle(1), turtle(2),...).

Report Output Tab



Report File Name

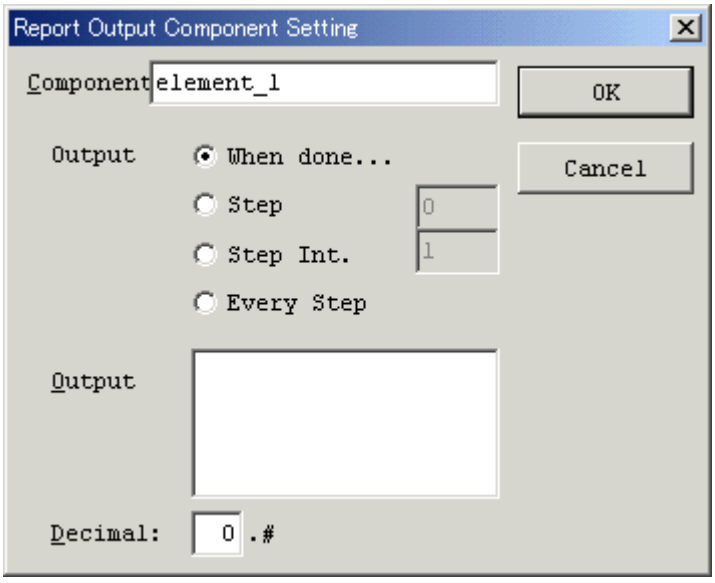
This sets the name of the file for report-file output. Clicking Set displays a dialog box for saving, where you can specify a file name and location of the report-file.

Delimiter

You can choose any of four types of separator characters; Tab, Comma, Space, or Other.

Report Component List

Use the Add button to add components you want to output in the report file, use the Edit button to edit components, and use the Delete button to delete components.
Clicking Add displays the Report Output Component Setting dialog box.



Component Name

In this field you can give the report output component a name of your choosing.

Output

This selects the timing for outputting the components to the report file.

Output Value

Enter the variable you want to output.

Show Fractional Numbers

This sets how many digits to the right of the decimal point are output.

2.2.5 Control Panel Settings

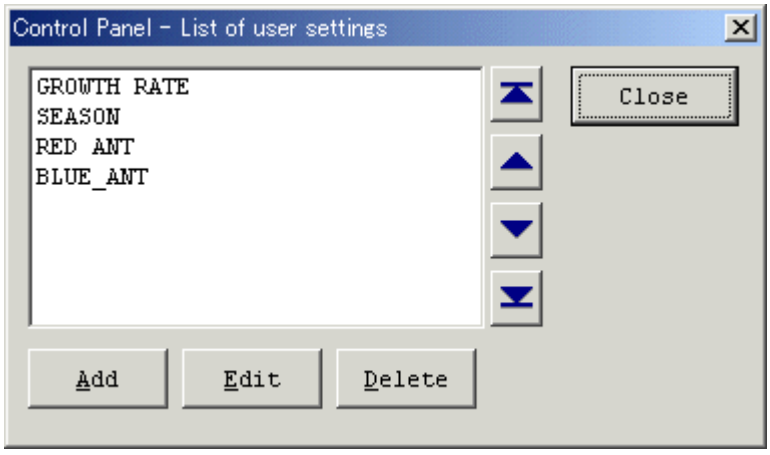
Control Panel is used to start a simulation, pause a simulation partway through, or quit a simulation. You can also change the variables immediately under World, while execution is in progress.

To start a simulation, click the Run button. To quit a simulation, click the Stop button. To pause a simulation, click the Pause button.

Clicking the Step button executes the simulation one step at a time. Each click of the button executes one step, after which the simulation pauses.

Making Settings for the Control Panel

To make settings for the Control Panel, go into the Settings menu and select Control Panel Settings.



Add

This adds setting items displayed in the Control Panel window.

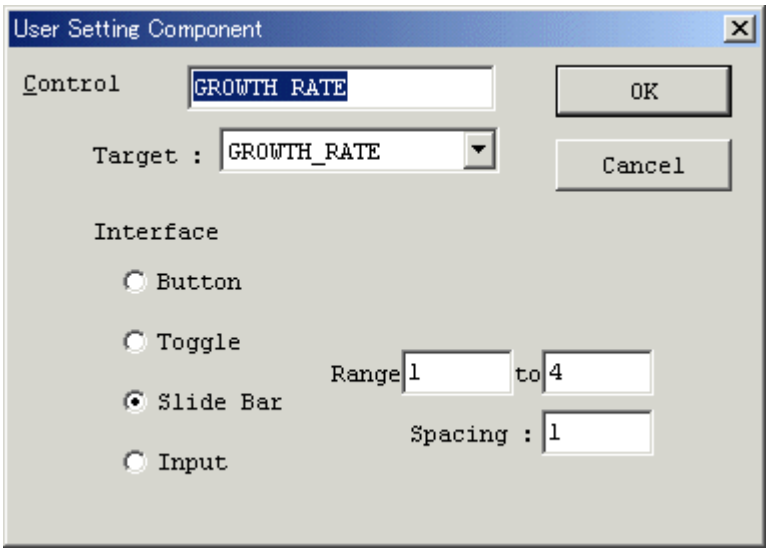
Edit

This is used to edit existing setting items.

Delete

This is used to delete existing setting items.

Clicking Add or Edit displays a User Settings dialog box.



Control Name

Enter an easy-to-understand name of your choosing in this setting.

Setting Target

Select the variable you want to manipulate with the Control Panel. Note that you can select only variables immediately under World.

Interface – Button

Select this when you want to assign a value when the button is ON.

Interface – Toggle Button

Select this when you want to assign respective values when the button is ON and OFF.

Interface – Slider

Select this when you want to intermittently vary a value within specified range by dragging a slider to the left or right.

Interface – Direct Entry

Select this when you want to directly type a value to be assigned to the variable.

2.3 Simulation Execution Features

After making the Control Panel settings as require, you can run, pause, and stop simulations, perform stepped execution, and change variables during simulation.
To execute a simulation, use the Control Panel window.

Run button

Click this to start a simulation.

Step button

This executes a simulation one step at a time. Each click of the button executes one step, after which the simulation pauses.

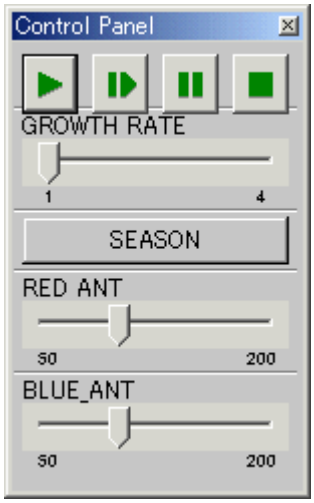
Pause button

Click this to pause a simulation.

Stop button

Click this to quit a simulation.

When you push [ESC] key, exit a simulation. If you have specified variables to change in the Control Panel settings, then several elements are added to the Control Panel window.



Button Used

Once the button is clicked, it remains ON.

Toggle Button Used

The button is ON when clicked once, and switched OFF when clicked a second time.

Slider Used

By dragging with the mouse, you can change the value freely within the Range entered in the Control Panel Settings dialog box.

Direct Entry Used

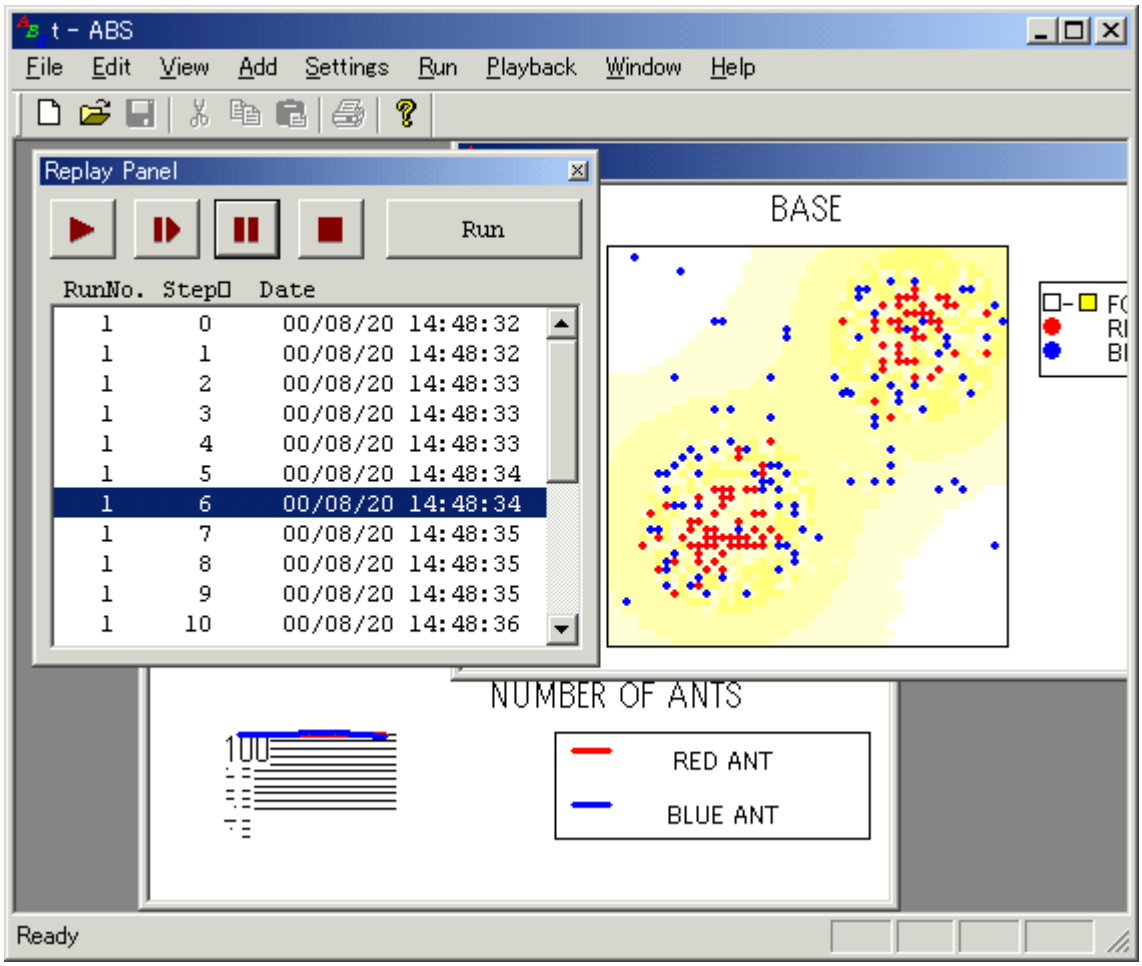
Click to select, then type a value directly from the keyboard.

2.4 Log Playback Feature

To use this feature, you must first make settings, run a simulation, and generated a log file.

When you open the log file, you can replay the simulation. When you do this, the Playback menu becomes available for selection.

Selecting Run in this state displays the Playback panel and replays the simulation.



Playback button

This button performs continuous playback to the end.

Step Playback button

Each click of this button plays back one step.

Pause button

Clicking this during playback pauses the playback.

Stop button

This button stops playback.

Run Simulation button

When you pause at a step and click this button, you can then set the values in that step to their initial values and execute the simulation again. If you want to save a new log file when you execute the simulation again, you need to redo the settings in the Log File Settings dialog box.

Playback List Panel

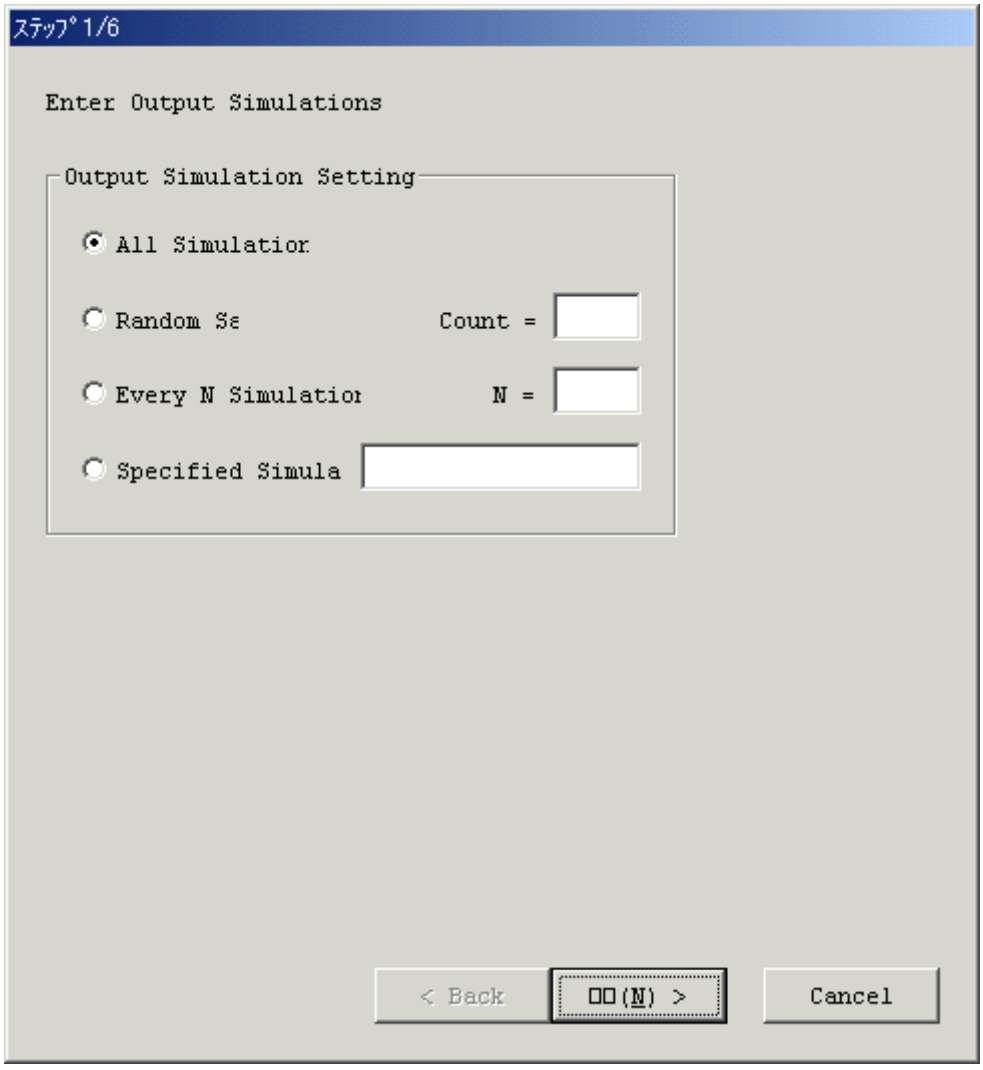
The step numbers, together with the date and time of simulation execution, are listed in ascending order on the time axis. When you pause at a step and click the location you want on this list, you can display the step's actual output. You can also display their images by using the arrow keys instead of clicking.

2.5 Analytic File Output Feature

To use this feature, you must first make settings, run a simulation, and generated a log file.

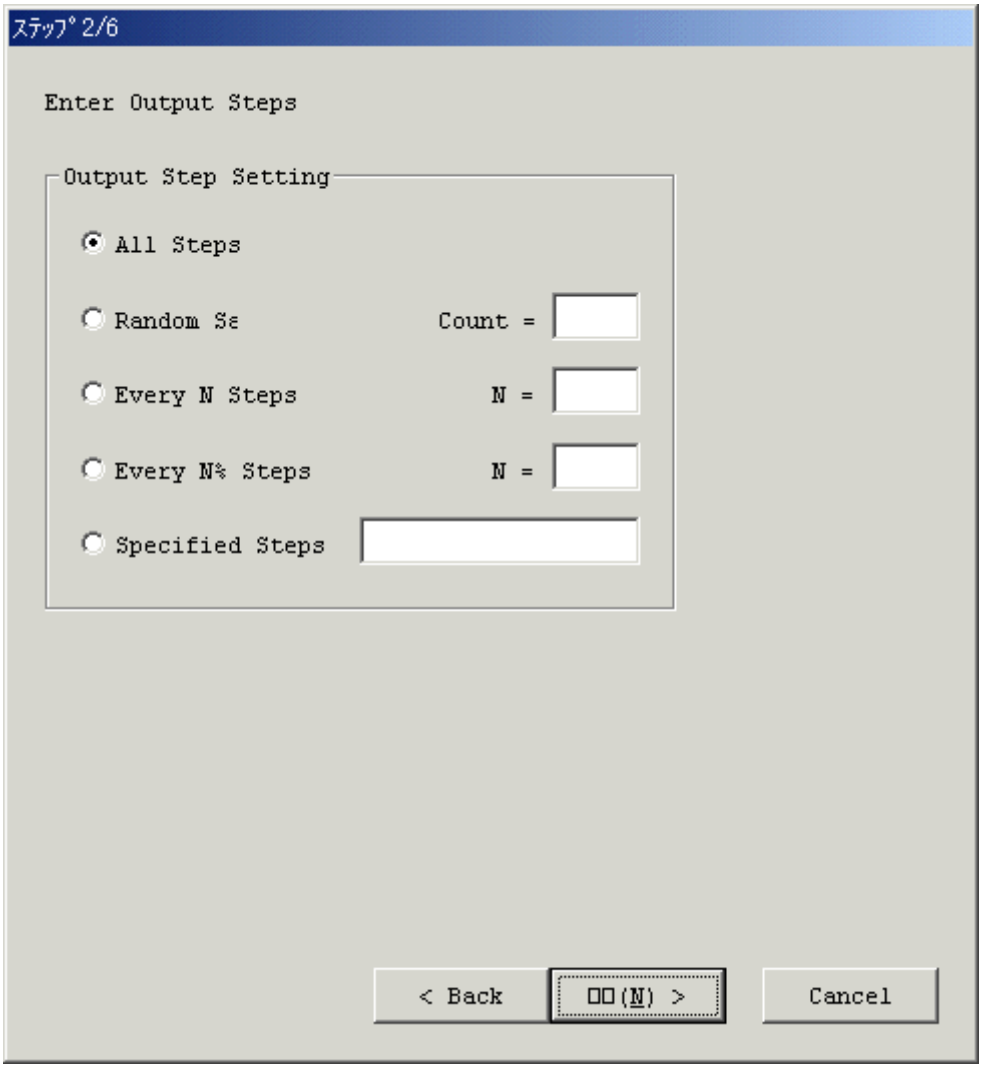
When you open the log file, you can get analitic file. When you do this, the Analytic file menu becomes available for selection.

Selecting Analytic file in this state displays the Analytic file output dialog(1/6) and sets output formats.



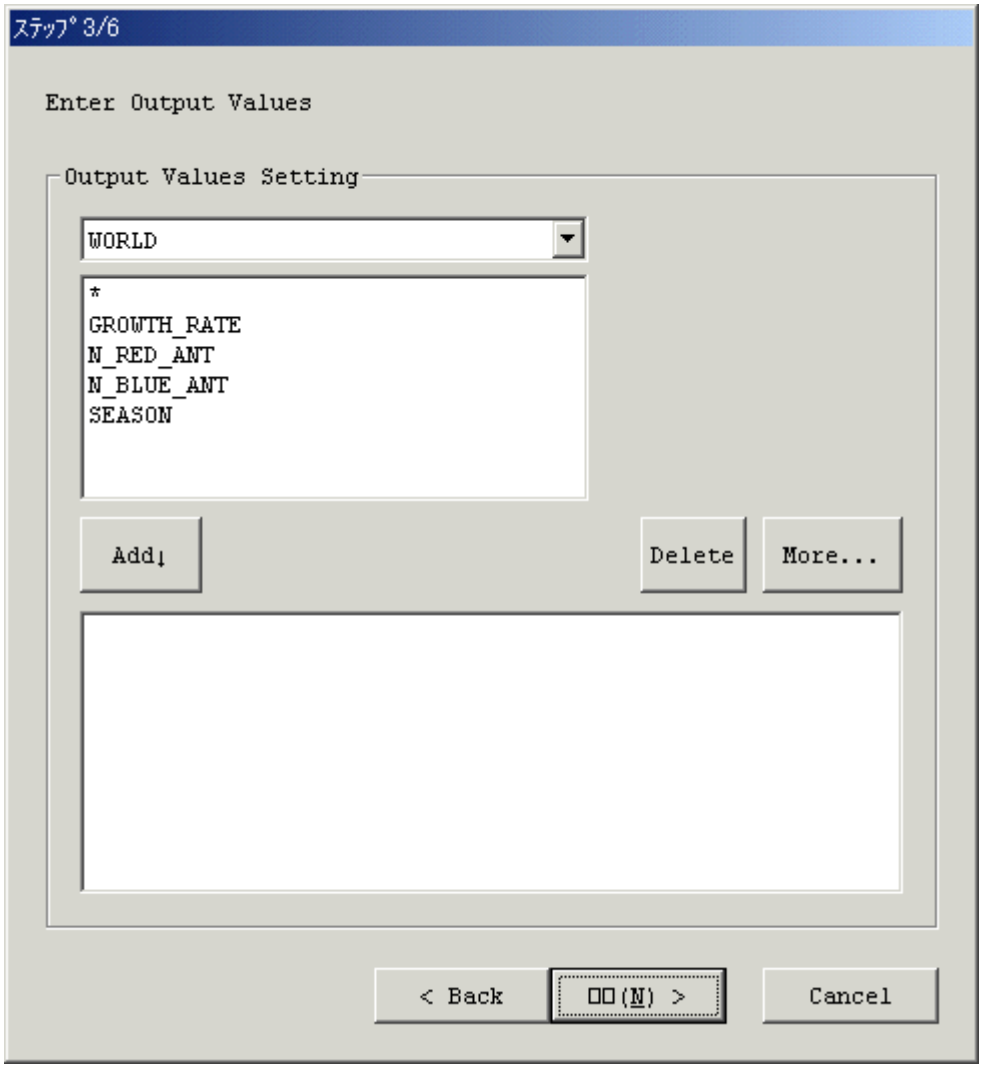
Output Simulation Setting

When a logfile contains multiple simulations, sets simulations for output data.



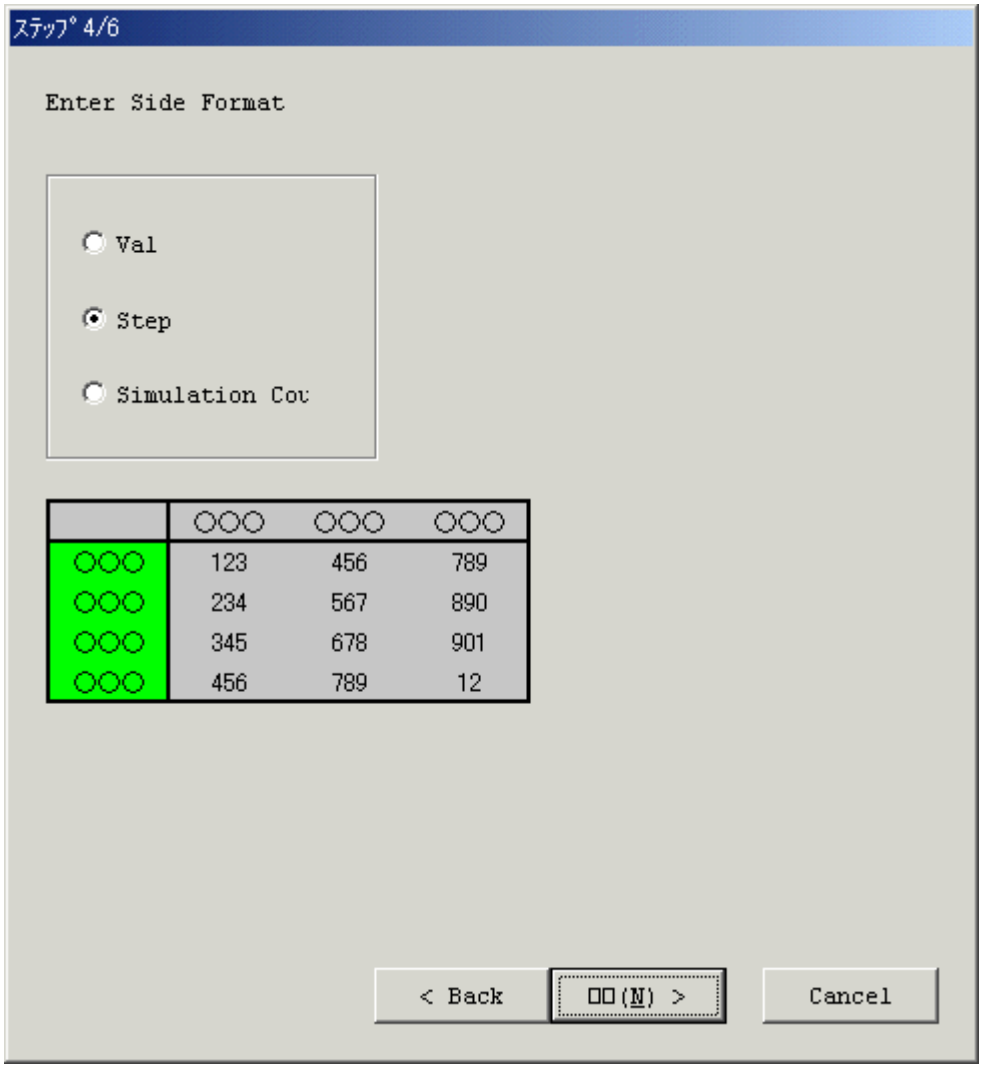
Output Step Setting

Enter the step count you want to output data.



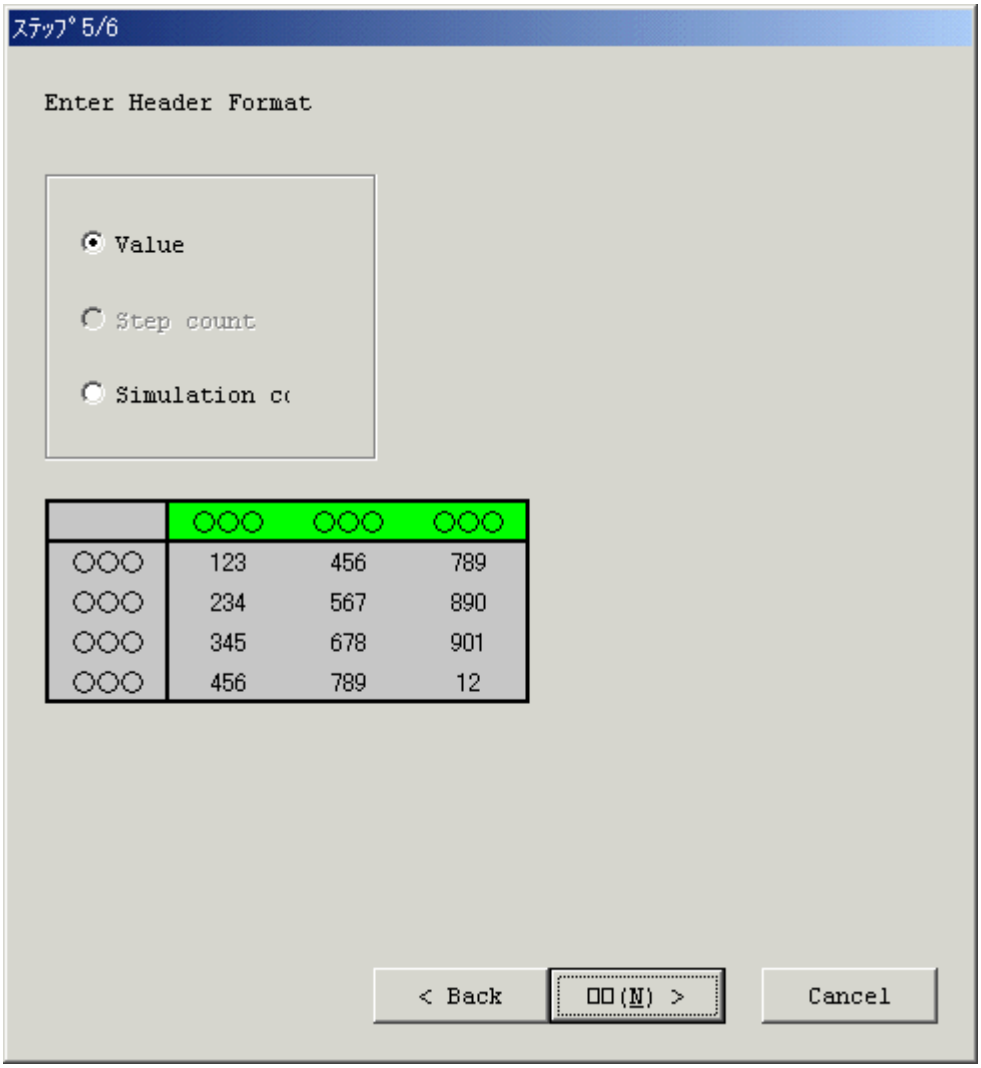
Output Values Setting

Set values for output data. Select an Agent, show values series, click Add button for ouput values displays this screen. You can select many values. Clicking Delete button to except entries. Click More button, you can set for details



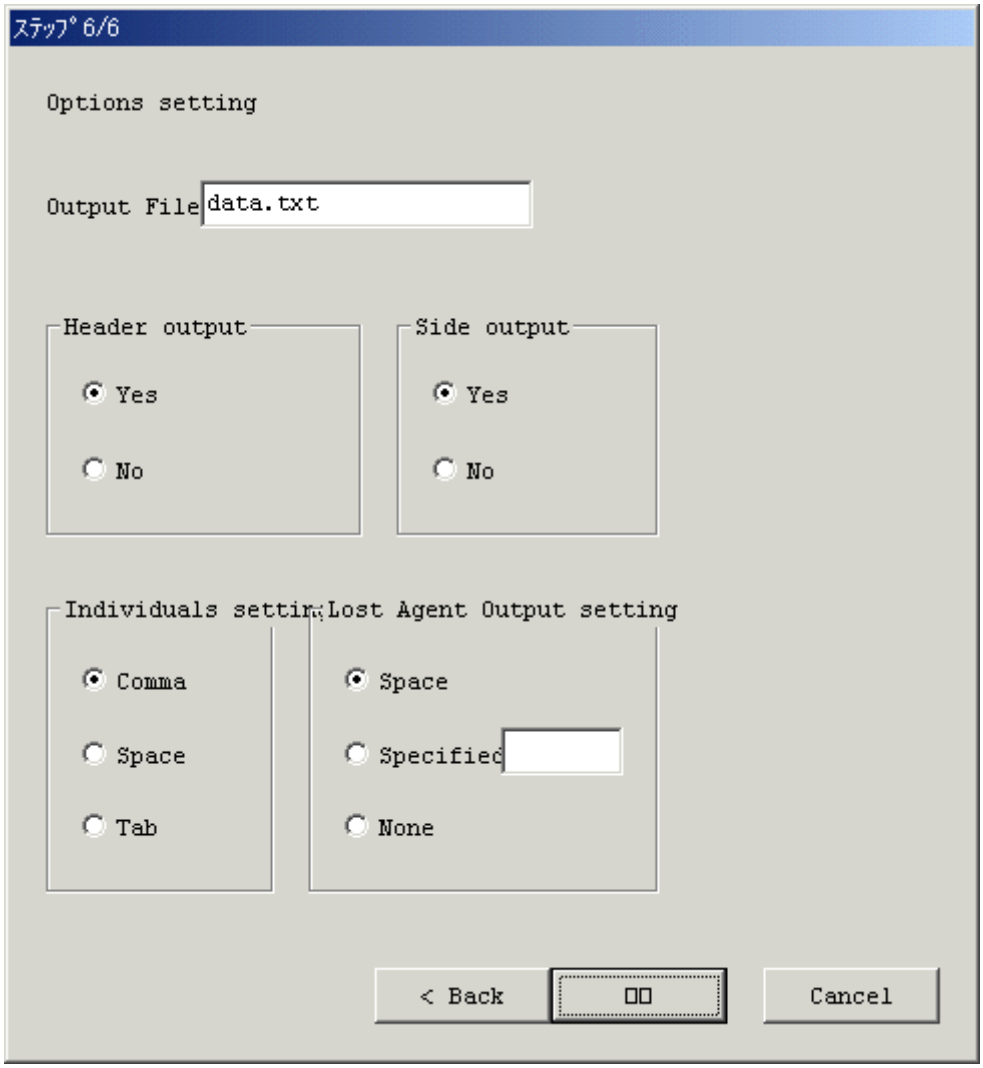
Side Format Setting

Set side format for output data.



Header Format Setting

Set header format for output data.



Output file

Set file name for output data.

Header Output

Set Header format for output data.

Side Output

Set Side format for output data.

Separator

This selects the separator character for output data.

Deficit Data

This selects the deficit data for output data.

2.6 Help Feature

Descriptions of Models

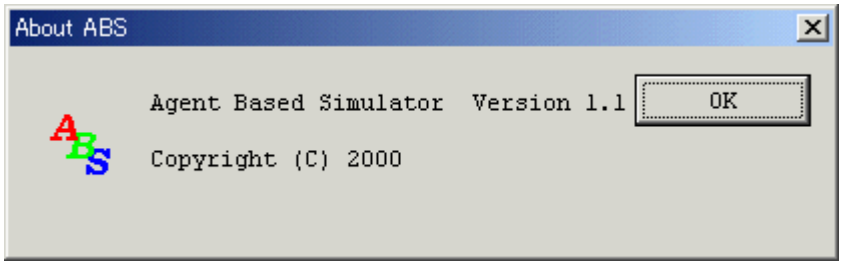
If a model description file is already embedded in the job file (see Rule Editor Settings), you can view the embedded model description file by going into the Help menu and selecting Model Description.

Viewing the Help File

Going into the Help menu and selecting Show Help displays the standard help file. This is mainly a reference for agent-rule syntax. Use it together with this manual.

About Agent Based Simulator

Going into the Help menu and selecting About displays the following window that provides information about the version of *Agent Based Simulator*.



2.7 Debug Screen Feature

Debug Screen Output

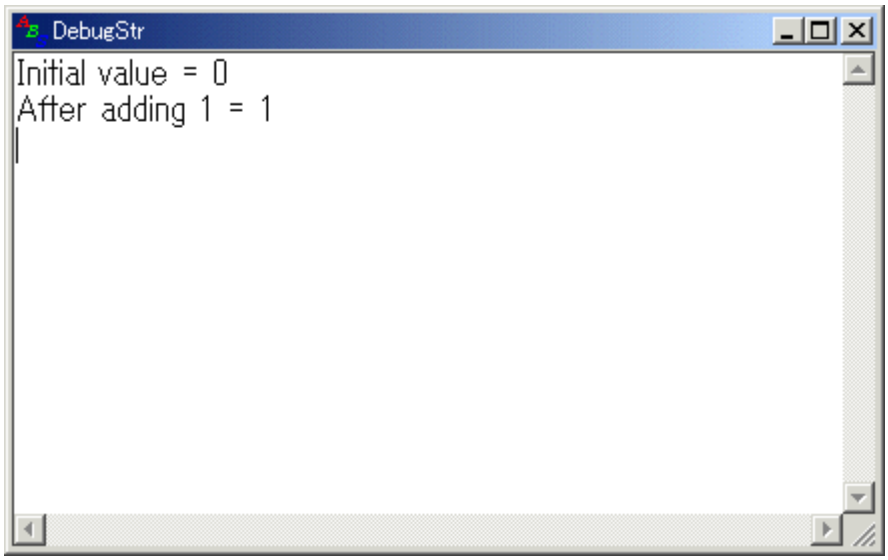
You can output a debugging screen by including the _DebugStr function in rules. _DebugStr is an internal function to display debugging information.

Format: _DebugStr(*argument*)

If the argument is a text string, it must be enclosed in quotation marks ("").
For example,

```
Agt_Init{
    Dim X as Integer
    X=0
    _DebugStr ("Initial value = " & X )
    X=X+1
    _DebugStr ("After adding 1 = " & X )
}
```

Execution Result :



Chapter 3

Agent Rule Syntax

This section is the specification for the language used in agent rules for the *Agent Based Simulator*. The content may be somewhat advanced for persons with no programming experience. Please study it along with a commercially available syntax guide. The language used in rules is basically in line with that of Microsoft Visual Basic.

3.1 Overall Structure of Agent Rules

An agent rule is written with the following structure for each agent. A rule is a collection of functions.

```
Agt_Init{
    Local declaration block
    Execution block
}
Agt_Step{
    Local declaration block
    Execution block
}
User-defined function{          (User-defined functions are not necessarily required)
}
```

3.2 Special Functions

Agt_Init

This is a function that is executed only once, when agents are created while running a simulation. The name Agt_Init has a special meaning, and Agt_Init is a reserved word that cannot be used for any other purpose. The format is as follows.

```
Agt_Init{
    Variable-type declaration block
    Execution block
}
```

Agt_Step

This is a function that is executed repeatedly until the simulation ends. The name Agt_Step has a special meaning, and Agt_Step is a reserved word that cannot be used for any other purpose. The format is as follows.

```
Agt_Step{
    Variable-type declaration block
    Execution block
}
```

3.3 User-defined Functions

You can freely define user-defined functions. Like name constants declared in the variable-type declaration block, functions defined here can be called from the Agt_Init function, Agt_Step function, or user-defined functions in the relevant agent rule. However, that cannot be called from agent rules for other agents.
The format is as follows.

Function statement

```
Function function name (parameter declaration) As function return-value type
{
    Variable-type declaration block
    Execution block
    Return (expression)
}
```

Function

This declares that a user-defined function is defined starting here.

Function name

You can name this any way you like. However, reserved words or already-declared variable names and name constants cannot be used, because these may confuse *Agent Based Simulator*.

As *function return-value type*

This is stated when the function must return a value. When this is omitted, the function cannot return a value. For the function return-value type, specify the type of the value that the function returns. The method of specifying this is the same as for the variable type.

Sub statement

```
Sub function name (parameter declaration)
{
    Variable-type declaration block
    Execution block
}
```

Sub

This declares that a user-defined function is defined starting here.

Function name

You can name this any way you like. However, reserved words or already-declared variable names and name constants cannot be used, because these may confuse *Agent Based Simulator*.

Parameter Declaration

When a parameter is passed to the function, the following format is used to declare it.

```
Variable name 1 As variable type, ... , Variable name n As variable type
```

(Examples)

```
Function Function2(a as Integer, b As Integer, c As Double) As Integer{
}
Sub Function2(a as Integer, b As Integer, c As Double){
}
```

Differences between Function and Sub

When a user-defined function is executed, if you want to use the value of the result (the return value) directly in an execution statement, use Function. In other cases, use Sub. For example,

```
1 Agt_Step{
2     Dim a As Integer
3     a = Function1(5,3)
4 }
5 Function Function1(b As Integer, c As Integer) As Integer{
6     Dim answer1 As Integer
7     Answer1 = b + c
8     Return (answer1)
9 }
```

In line 2, we declare variable a of Integer data type. Next, we pass the values 5 and 3 to the user-defined function Function1, and assign its calculation result to a.
In the user-defined function (starting at line 5), we declare the variable answer1 of Integer data type (line 6), assign the calculation result of b + c (in this case, 5+3) to answer1 (line 7), then return the value of answer1 to the Function1 location in Agt_Step.
That is, this example says to assign the answer of the calculation of 5+3 to the variable a. However, if it's not necessary to assign the calculation result to the a variable, then there is no need for the user-defined function to return a value. In such cases, use Sub instead of Function.

3.4 Rules for Names

The names of variables and functions used in agent rules must follow the convention below.
The first character of a name must be a letter.

- *Each of the second and subsequent characters must be a letter, numeral, or under-score "_".*
- *A name must be 100 characters or fewer.*
- *Reserved words (see section 3.8) cannot be used as names.*

Important : Letters are not case-sensitive.

For examples, Sum, sum_x, and sum100 are correct names. SUM, Sum, and sum are all considered to be identical. The following names are incorrect;

- 1x *A numeral cannot be used as the first character.*
- x$ *A special symbol cannot be used.*
- next *Reserved words cannot be used.*

3.5 Variable Declaration Block

This is a section that declares variables to be used only within the relevant function. Variables must be declared before they are used. If a variable is used without defining it first, an "undefined" error occurs during compiling.
Variables declared here are called "local variables". They can be referenced or changed only within the function where they are declared. Local variables are initialized when execution of the function starts, and are destroyed when execution of the function ends.
When initialized, variables of String data type are reset to a null string (""), and other variables are reset to 0 (zero).

3.5.1 Declaration of Variables

The format is as follows. This may be omitted if local variables are not used.

Dim *variable name 1* As *variable type* [, ... , *variable name n* As *variable type*]

(Examples)

```
Dim x As Integer
Dim x1 As Double, x2(10) As Double, x3(10,20,30) As Double
```

Dim

This is a reserved word that indicates the start of variable declaration.

Variable name

This is written using the following format.

(1) For a simple variable

Variable name

(2) For an array variable
This is declared using the following format.

Dim *variable name 1 (m1, ... , mn)* As *variable type*, ...
variable name2 (m1, ... , mn) As *variable type*

m1: Number of array elements in the first dimension −1
mn: Number of array elements in the *n*th dimension −1

There is no particular restriction on the number of dimensions.

(Examples)

```
Dim dx(10) As Integer
//    Declares a one-dimensional array having 11 elements
//     from dx(0) to dx(10).
Dim ds(2,3) As String
//    Declares a two-dimensional array having 3*4 elements;
//     ds(0,0), ds(0,1), ds(0,2), ds(0,3)
//     ds(1,0), ds(1,1), ds(1,2), ds(1,3)
//     ds(2,0), ds(2,1), ds(2,2), ds(2,3)
```

As

This is a reserved word indicating that the variable type follows.

3.5.2 Variable Type Declaration

There are eight variable types:

Type	Name	Value range
Boolean data type	Boolean	True or False
String data type	String	0 to 1,000 characters
Integer data type	Integer	–2,147,483,648 ～ 2,147,483,647
Real data type	Double	$-1.79769313486232 \times 10^{308}$ ～ $4.94065645841247 \times 10^{-324}$ (when negative) $4.94065645841247 \times 10^{-324}$ ～ $1.79769313486232 \times 10^{308}$ (when positive)
Agent data type	Agent	Agent name defined in Tree
Object data type	Object	Agent entity value
Collection data type	Collection	Array of variables of Object data type
Space data type	Space	Space name defined in Tree

3.6 Execution Block

An execution block is composed of a group of executable statements and sets forth the action of the agent. Block means a series of zero or more executable statements.
Executable statements include dummy statements, assignment statements, conditional statements, loop statements, jump statements, and the like.

3.6.1 Dummy Statements

Dummy statements perform no execution. They are used to make programs more readable.
(Example)

```
If x == 1 And y == 1 Then
Else
    Z = 0
End If
```

The above example is equivalent to the following one.

```
If x <> 1 Or y <> 1 Then
    z = 0
End If
```

3.6.2 Assignment Statements

Assignment statements assign values to variables. The format is as follows.

```
Variable name = Expression
```

Variable name

This is either a variable declared in an agent rule, or an agent variable established using the GUI (graphical user interface). The format is as follows.

(1) For a variable declared within the agent rule

- For a simple variable (zero dimensions)

```
Variable name
```

(Example)

```
x
```

- For an array variable

```
Variable name (Expression indicating the element number of the first dimension, ... ,
                expression indicating the element number of the nth dimension)
```

(Examples)

```
x(0)   // For a one-dimensional array
y(i)   // For a one-dimensional array
z(i,j)  // For a two-dimensional array
```

(2) For an agent variable

```
agent name.variable name
```

Agent name

This states the path name of the agent.

(Examples)

```
// (Example 1) When specified with the relevant agent as the origin
Up.Up.agent_b                  // Up: Up one level in the hierarchy
// (Example 2) When the agent is an array
World.agent_a(i).Agent_b
// (Example 3) When specified with the World agent as the origin
world.Agent_a.agent_b(i)
// (Example 4) When specifying the relevant agent
My.
```

Variable name

The format is the same as for variables declared within an agent rule.

(Examples of assignment statements)

```
a = 0
a = b ; c
a = b + Function_a(c)
a(i) = b
World.a = 0
World.a(i) = b + c(i)
World.Agent_a(i).b = c
My.a = 1
```

3.6.3 Expressions

An expression is a linear expression, or linear expressions joined by operators, including the following types.

- Arithmetic expression ..... x * y + Rnd() / 10
- Relational expression ..... If x > y Then
- Logical expression ..... If x > y And x > z Then
- Character expression ..... multi_agent = "multi" & "agent"

A linear expression may be any of the following.

- Numeric constant
- Character-string constant
- Variable name (the same as a variable name in an assignment statement)
- Function call
- – linear expression
- Not plus linear expression (Not is a bitwise operator)
- (Expression)

(Examples of linear expressions)

0	Constant
x	Variable name
x(i)	Variable name
Function_a(a,b)	Function call
-x	– linear expression
-Function_a(a,b)	– linear expression
Not a	Not plus linear expression
(a + b)	(expression)
-(-a + b)	– linear expression

The following summarizes the operators that can be use in expressions, and their precedence.

String operators

Type	Operator	Precedence	Meaning
Others	`()`	1	Expression enclosed in "()"
	`Function`	2	Function call
Arithmetic operators used in arithmetic expressions	`^`	3	Exponentiation, x^n
	`-`	4	Negation, $-x$
	`*`	5	Multiplication, $x \times y$
	`/`	5	Floating-point division (result is floating-point number), x / y
		6	Integer division (result is integer, x y
	`Mod`	7	Modulo (result is remainder of integer division)
	`+`	8	Addition, $x + y$
	`-`	8	Subtraction, $x - y$
String operator	`&`	9	String concatenation ("ab" & "cde" → "abcde")
Relational operators used in relational expressions	`= =`	10	equal (note difference from "=")
	`< >`	10	Not equal (identical to !=)
	`! =`	10	Not equal (identical to <>)
	`<`	10	Less than
	`< =`	10	Less than or equal
	`>`	10	Greater than
	`> =`	10	Greater than or equal
Logical operators used in logical expressions	`Not`	10	Logical negation
	`And`	11	Logical conjunction
	`Or`	12	Logical disjunction
	`Xor`	13	Logical exclusion
Assignment operator	`=`	14	Assignment (assign result of expression), variable name = expression

3.6.4 Function Calls

In terms of syntax, a function call is a linear expression. A function call may be used in an arithmetic, relational, or logical expression, or may be used as an independent statement. Note that a function with no return value can be used only as an independent statement.

Function name (argument 1, argument 2, ...)

Argument

The number of arguments and their types must match what has been defined. Only variable names can be specified as arguments.

3.6.5 Conditional Statements

Conditional statements cause processing to branch according to certain conditions.

(1) When the expression evaluates to true, the block is executed.

If *expression* Then
    Block statement
EndIf

(2) When the expression evaluates to true, block 1 is executed. When it evaluates to false, block 2 is executed.

```
If expression Then
    Block statement 1
Else
    Block statement 2
End If
```

(3) When the value of the expression is true, the corresponding block is executed.
When all expressions evaluate to false, block *n* is executed.

```
If expression 1 Then
    Block statement 1
ElseIf expression 2 Then
    Block statement 2
ElseIf expression 3 Then
    Block statement 3
 • • •
Else
    Block statement ,•
End If
```

3.6.6 Loop Statements

Loop statements perform repetitive processing.

For statement

This is used to repeat processing a specific number of times. The format is as follows.

```
For loop variable = start value To end value (Step step value)
                                        // When Step value is omitted, step defaults to 1
    Block statement
Next loop variable
```

(Example)

```
total = 0
For i=1 To 10 Step 1
    total = total + i
Next i
```

Do While statement

This is used to repeat processing while an expression evaluates to true. The format is as follows.

```
Do While expression
    Block statement
Loop
```

Do Until statement

This is used to repeat processing while an expression evaluates to false, that is, until it evaluates to true.

```
Do Until expression
    Block statement
Loop
```

3.6.7 Jump Statements

Jump statements change the flow of control.

Goto statement

This is used to jump to a specified location. The format is as follows.

```
Goto jump-destination label name
    • • •
Jump-destination label name:
    • • •
```

(Example)

```
Do While x > 0
    Do while y > 0
        If err_flag == True Then
            Goto error_handling
        End If
    Loop
Loop                        // Jump to specified label
Goto normal_processing
error_handling:
```

Break statement

This is used to break out of a loop.

(Example) To escape from a While loop

```
Do While conditional expression
    Do While conditional expression
        • • •
        If conditional expression for escape Then
            Break
        End If
        • • •                       // Escape one level
    Loop
    • • •
Loop
```

(Example) To escape from a For loop

```
For i=0 To 10 Step 1
    For j=0 To 10 Step 1
        • • •
        If conditional expression for escape Then
            Break
        End If
        • • •                          // Escape one level
    Next j
    • • •
Next i
```

3.6.8 Other Statements

Return statement

When function execution ends, this statement returns control of execution to the location where called from. The function with a return value can return a value at this time. The format is as follows.

```
Return (expression)
```

Important : There is not limit on the number of Return statements that can appear within a function.

Important : The following cases result in a compile error.

- *When the function is defined as returning a value and an expression is omitted.*
- *When the function is defined as returning a value and the data type of the return value differs from the data type of the expression.*
- *When the function is defined as not returning a value and an expression appears.*

3.7 Internal Functions

Agent based simulator has predefined functions, called internal functions. These functions can all be called from within functions.
The internal functions are listed below.

3.7.1 Numerical-calculation Functions

Number	Function name	Action
1	`Abs`	Calculates the absolute value
2	`Atn`	Calculates the arctangent (trigonometric function)
3	`Cos`	Calculates the cosine (trigonometric function)
4	`Exp`	Calculates e^x
5	`Int`	Truncates the fractional part of a real number and returns the first integer less than or equal to the real number
6	`Log`	Calculates the natural logarithm $\log_e x$
7	`Rnd`	Returns a random number greater than or equal to 0.0 but less than 1.0
8	`Round`	Rounds off the portion of a number to the right of the decimal point
9	`Sin`	Calculates the sine (trigonometric function)
10	`Sqr`	Calculates the square root
11	`Tan`	Calculates the tangent (trigonometric function)

3.7.2 String-manipulation Functions

Number	Function name	Action
1	`Left`	Extracts a string from the left side
2	`Len`	Returns the number of characters of a string
3	`Mid`	Extracts a string from a specified position
4	`Right`	Extracts a string from the right side
5	`Strcomp`	Compares two strings

3.7.3 Data-manipulation Functions

Number	Function name	Action
1	`CDbl`	Converts the value of an expression to Double data type
2	`CInt`	Converts the value of an expression to Integer data type
3	`CStr`	Converts the value of an expression to String data type
4	`CBool`	Converts to False when an expression evaluates to 0, and converts to True otherwise

3.7.4 Agent Functions

Number	Function name	Action
1	_CountAgent	Returns the number of instances of a specified agent
2	_ViewCountAgent	Returns the number of instances of surrounding agents in two-dimensional space (grid model or hexagon model), centered at specified coordinates
3	_ViewCountAgent2	Returns the number of instances of surrounding agents in two-dimensional space (grid model or hexagon model), centered at specified coordinates (All-mode available)
4	_RandomPutAgent	Randomly places a specified agent
5	_MoveToSpace	Seeks and moves to a surrounding unoccupied site, centered on specified coordinates
6	_MoveToCollectionSpace	Seeks and moves to a surrounding unoccupied site, centered on specified coordinates, not overlapping with agents belonging to a specified collection
7	_MoveToRichValue	Seeks and moves to a surrounding site in two-dimensional space, centered at specified coordinates, where the value of a specified variable is largest
8	_Forward	Advances forward (direction of advance is determined by the Direction variable)
9	_Turn	Changes the orientation (the Direction variable is modified)
10	_CreateAgent	Creates an agent
11	_LinkAgent	Changes the linking of an agent
12	_KillAgent	Destroys an agent
13	_SpecifyKillAgent	Returns the value of the Kill flag
14	_SpecifyAgent	Returns the agent type of a specified object

3.7.5 Collection Functions

Number	Function name	Action
1	_CountCollection	Returns the number of objects in a collection
2	_GetObject	Returns the object at a specified position in a collection
3	_CollectAround	Returns the collection of agents around specified location coordinates
4	_AddCollection	Adds an object to a collection
5	_RemoveCollection	Removes a specified object from a collection
6	_CopyCollection	Copies a collection
7	_CollectAgent	Creates a collection of a specified agent name
8	_InitCollection	Initializes a collection
9	_CloseCollection	Releases a collection
10	_MakeMergeCollection()	Returns a new collection formed by merging two collections (with no redundant elements)
11	_MakeJoinCollection()	Returns a new collection formed by joining two collections (redundant elements are permitted)
12	_MakeCommonCollection()	Returns a new collection formed of elements (objects) which are common to two collections
13	_MakeDiffCollection()	Returns a new collection formed of elements (objects) which are included in only one or the other, but not both, of two collections
14	_MakeDelCollection()	Returns a new collection formed by excluding elements in collection 2 from collection 1
15	_GetCollectionEntry()	Examines whether a specified object exists in the elements of a collection, and returns an integer greater than or equal to zero representing a sequential number (element number) from the starting element of the collection, or –1 if the object does not exist in the collection

3.7.6 Space Functions

Number	Function name	Action
1	_SpecifySpace	Returns the type of a specified space
2	_GetWidthSpace	Returns the horizontal width of a specified space
3	_GetHeightSpace	Returns the vertical height of a specified space
4	_GetRideSpace	Returns the space on which a specified object rides

3.7.7 File Input-Output Functions

Number	Function name	Action
1	_OpenFileCSV	Open CSV file
2	_ReadFileCSV	Read one row from CSV file
3	_WriteFileCSV	Write one row to CSV file
4	_CloseFileCSV	Close CSV file

3.7.8 Other Functions

Number	Function name	Action
1	_SpecifyLoop	Returns the loop setting of a specified space
2	_GetCountStep	Returns the present step count
3	_GetCountSimulationNumber	Returns the present simulation execution count
4	_ExitSimulation	Exits a simulation
5	_ExitSimulationMsg	Outputs a string to a message and exits a simulation
6	_DebugStr	Displays a string on the Debug Screen
7	_Shell	Execute a runnable program

3.8 Reserved Words

When you write an agent rule, you cannot use reserved words for variable names, user-defined function names, or the like. The names of internal functions also cannot be used. Reserved words are listed below.

Constants

True	Indicates a true value (Boolean data type).
False	Indicates a false value (Boolean data type).
Color_Red	Indicates the color red.
Color_Green	Indicates the color green.
Color_Blue	Indicates the color blue.
Color_Yellow	Indicates the color yellow.
Color_Cyan	Indicates the color cyan.
Color_Mazenta	Indicates the color magenta.
Color_Black	Indicates the color black.
Color_White	Indicates the color white.

Type names

Void	No valid data type (used as the type for the return value of a function)
Boolean	Boolean data type
Double	Real data type
Integer	Integer data type
String	String data type
Agent	Agent data type
Object	Object data type
Collection	Collection data type
Space	Space data type

Operators

And	Logical conjunction
Mod	Modulo
Not	Logical negation
Or	Logical disjunction
Xor	Logical exclusion

Execution control

Do	Used in Do While and Do Until statements
While	Used in Do While statements
Until	Used in Do Until statements
Loop	Used in Do While and Do Until statements
If	Used in If statements
Then	Used in If statements
Else	Used in If statements
ElseIf	Used in If statements
End	Used in If statements
For	Used in For statements
To	Used in For statements
Step	Used in For statements
Next	Used in For statements
Break	Used in jump statements
Goto	Used in Goto statements

Identifier declarations and references

Dim	Used in declarations
As	Used in declarations
By	Used in declarations
Val	Used in declarations
Function	Used in function definitions
Sub	Used in function definitions
Agt_Init	The name of a function executed only once, at the start of a simulation

Agt_Step	The name of a function executed repeatedly in a simulation
Up	Indicates the agent one hierarchical level higher
My	Indicates the relevant agent
World	Indicates the World agent
All	Indicates all agents (used in the _CollectAround function)

Others

Static	Reserved for future use
X	Indicates the spatial coordinate of an agent
Y	Indicates the spatial coordinate of an agent

3.9 Comments

You can write comments in agent rules. Because *Agent Based Simulator* ignores text in comments, you can write anything in comments. Because rules can easily become long processions of hard-to-understand text, we recommend commenting your programs liberally to make them easier to understand when inspected later. You can add comments at any place where a blank can be written.

The methods that can be used to write comments are given below.

(1) '

Everything from the ' to the end of the line is a comment.

(Example) In this case, sum = 0 is interpreted as a rule.

```
sum = 0                ' Initialize the total value
```

(2) //

Similar to (1).

(Example)

```
// Determine direction of advance, then move
direction = Rnd(360)
```

(3) /* ... */

Everything from the /* to the */ is a comment. This may span more than one line.

(Example)

```
/*
************************************************
* Turtle rule                  *
* Examination of Schelling's segregation model *
************************************************
*/
```

3.10 Error Correction

When a rule with a incorrect syntax is written in the Rule Editor, an error is displayed. Typical error messages and their remedies are given here.

1. A type name (Boolean, Integer, Double, String, Agent, Space, Object, or Collection) is required after "As".

   Remedy: Check the type declarations for the function's return value and variables.

2. "××.++" is undefined.

   Remedy: Do ×× and ++ exist? Also, check to make sure there are no typing errors.

3. _×××: The number of function arguments does not match the function specification (Call: *x* arguments, Function specification: *y* arguments).

   Remedy: Check for an error in the format of the arguments.

4. "××" is required after "++".

   Remedy: Make sure that ×× exists after ++.

Appendix

Creating More Advanced Models

The interesting thing about multi-agent models is that they affect each other based on local information. Local information could also be termed "limited information around the agents themselves". For instance, even in our real lives, we depend on limited information around ourselves to act and make decisions on a day to day basis. We also learn about events occurring elsewhere through the media and from other people. In simulations using earlier programming languages, however, it was rather difficult to produce such local interactions.

Agent Based Simulator was designed for manipulating agents, so you can program local interaction fairly easily. However, you still need to know some procedures and methods. This chapter describes some expressions that are unique to *Agent Based Simulator*. Give them a try, even if you already have experience with Visual Basic or the like. Because this chapter uses simple explanations that omit the descriptions of on-screen procedures in earlier chapters, if you're not sure about a procedure, go back to the previous chapters to check it.

A.1 A Model Using Internal Functions (Simple Segregation Model)

Let's try constructing a segregation model. This is a classic topic in the field of multi-agent simulators, put forth by Thomas Schelling.

This is based on a rule discovered by Schelling in his studies of the living patterns of residents in urban areas. It says that ethnic groups (or races) that initially live in an ethnically mixed state become clearly segregated over time. Various features have been added to the model included with the tutorial to make it easier to use, so we'll start by implementing a simple segregation model having only a minimum of elements.

The rules that define the segregation model are as follows.

1. There exist equal numbers of two types of turtles (red turtles and blue turtles).
2. The maximum occupancy of a single cell is one turtle. Two or more turtle cannot exist in a cell at a same time.
3. A turtle receives information from turtles in the eight cells surrounding it, and knows what percentage of the turtles are the same type as itself (this is the degree of happiness).
4. When a turtle's happiness is lower than a threshold value, the turtle moves to a nearby vacant cell.
5. When a turtle's happiness is higher than the threshold value, the turtle does not move.

The required parameters for the simple segregation model are as follows.

1. The numbers of red turtle and blue turtle agents are 500 each.
2. The threshold is 0.6 (60%).

A.1.1 Preparing the Simulation Components

The segregation model is a classic model using a two-dimensional space. In a space-using model, you ordinarily prepare the simulation components in the sequence of space, agents, and agent variables. Then, to obtain screen output during execution, you go into Output Settings and select Two-dimensional Map.

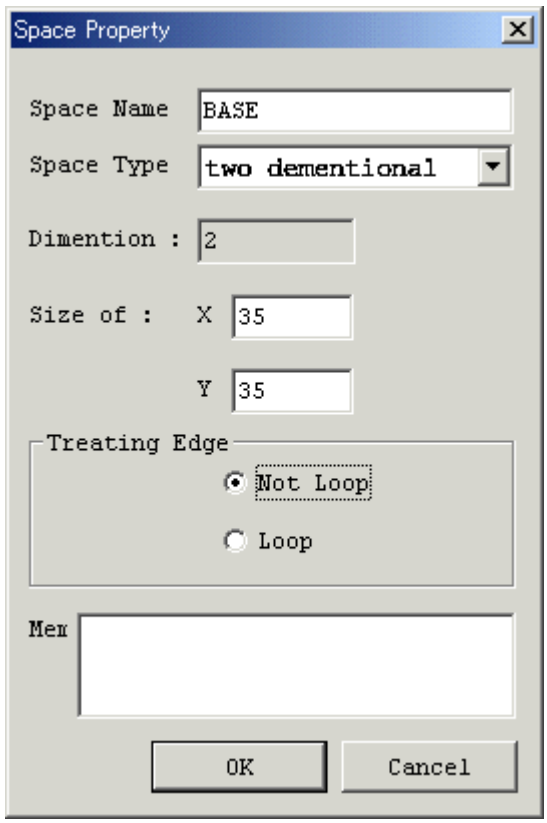
Creating a New Setting File

From the File menu, select New.

Adding the Space

Create a single new space component under the World hierarchy, then make the settings for the properties.

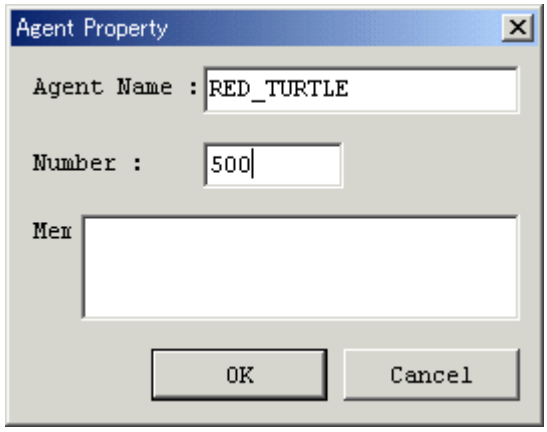
Name the space component "Two-dimensional Space". Select Grid Model, set 35 each for both X and Y, and set it to loop (wrap around).



Adding the Agents

Under the Two-dimensional Space hierarchy, create two new agents and make the settings for their properties.

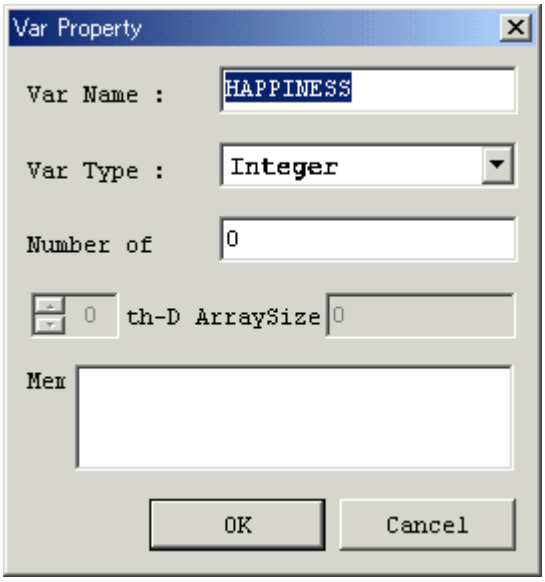
Name the agents Red Turtle and Blue Turtle, respectively. Set the number of agents to 500 for each agent.



Adding the Agent Variables

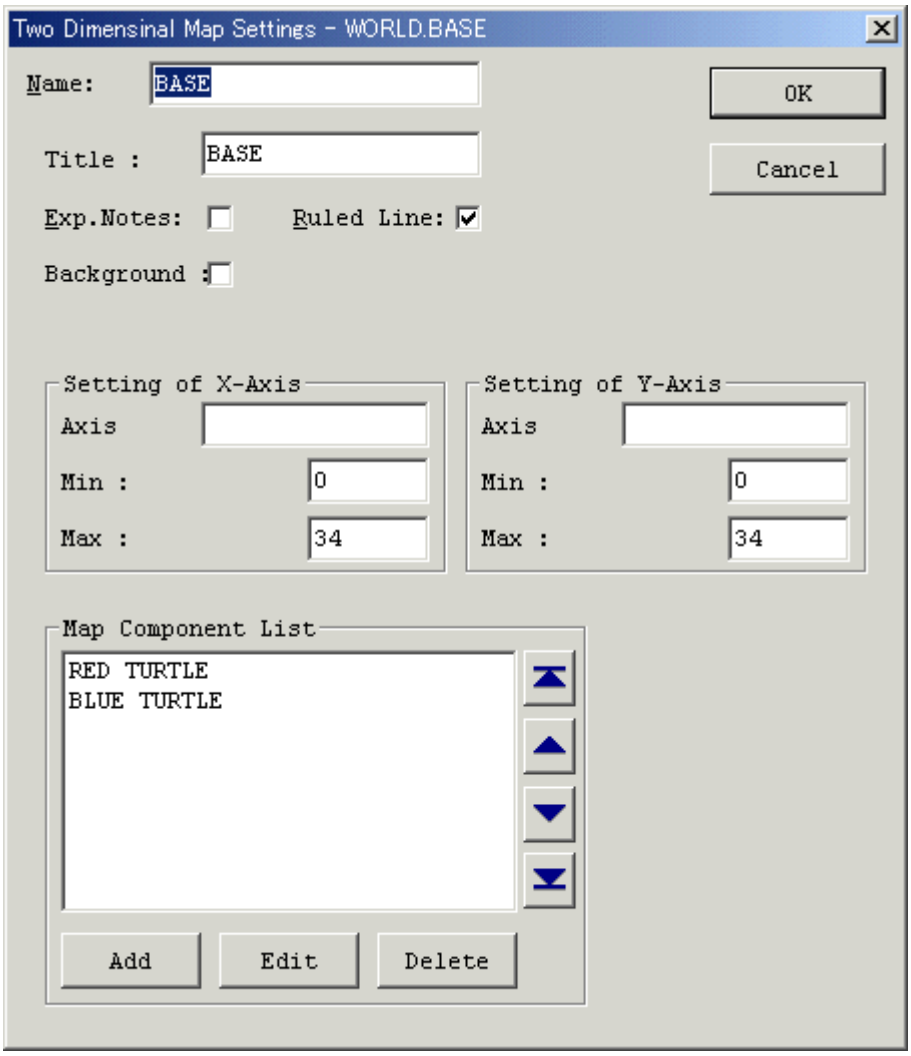
Create one new variable each under the hierarchies for Red Turtle and Blue Turtle.

Name the variable Happiness. Set the variable type to Double data type, and leave the number of dimensions at 0.



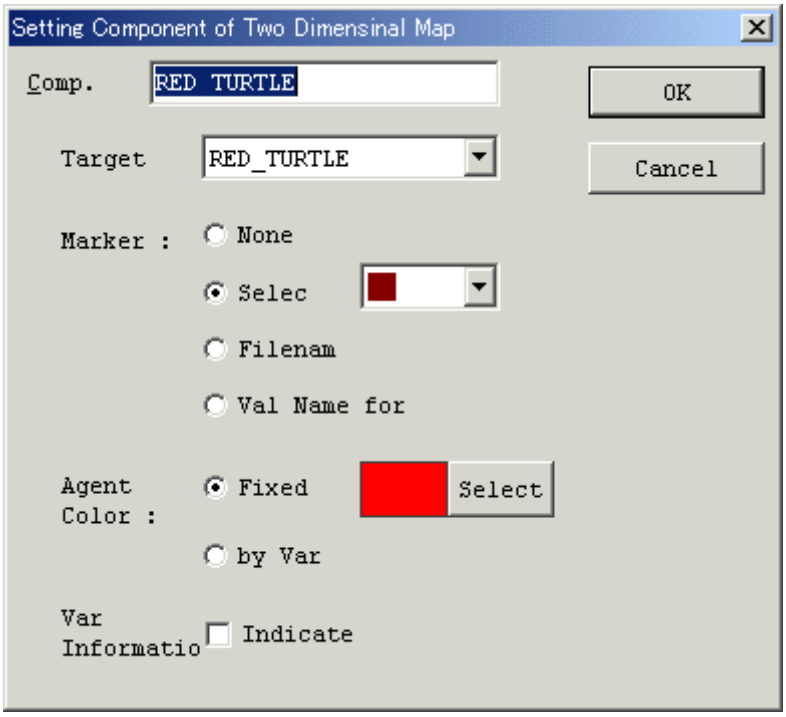
Adding the Two-dimensional Map

From the Settings menu, choose Output, then add 2D Map.



Set Map Name and Map Title to Two-dimensional Space.

At the Map Component List, click Add to add the component.



When the Two-dimensional Map Component Settings dialog box appears, set Component Name to Red Turtle, and set Output Target to Red Turtle as well (clicking the drop-down arrow • ¥ displays the options).

Leave Marker none, and set Agent Color to Fixed Color. If the color is not red, then click Select and choose the right color.

Leave Agent Variable Information un-selected.

Follow the same steps to add the Blue Turtle component. Be sure to modify the settings for Output Target and Agent Color correctly, or what's displayed will not be right.

Marker View

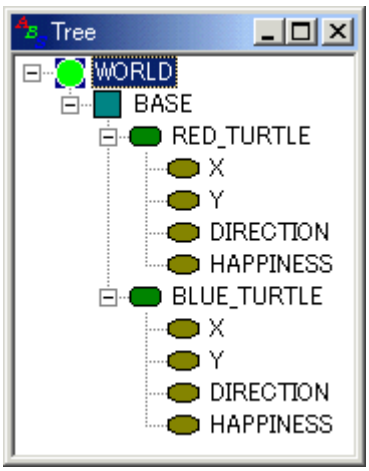
The feature that displays the agents on the two-dimensional map as circles, triangles, ×s, or other shapes is called Marker View. If you don't use Marker View, agents appear as squares aligned with the cells.

Agent Variable Information

In some cases, you may want to have direct knowledge of the state of variables under an agent's hierarchy. You can display variable values in the center of the agent view by selecting Agent Variable Information.

When you've finished making the settings, close the Output Item List dialog box.

Now you're done preparing the simulation components.



A.1.2 Writing the Rules

After you've structured the components for the simulation, the next step is to write out the rules. In a simple rule, the World rule is also simple; the initial rule just places each agent randomly. Notice that "false" appears at the end of _RandomPutAgent(). This indicates whether it is permitted to place multiple agents in a single cell. The rule for this model place no more than one agent per cell, so this is set to false.

Seg01.abs (World rule)

```
Agt_Init{
    _RandomPutAgent(World.twoDimensionalSpace.blueTurtle, false)
    _RandomPutAgent(World.twoDimensionalSpace.redTurtle, false)
}
Agt_Step{
}
```

Next let's look at the Red Turtle agent rule. The rule for red turtles is as follows.

Seg01.abs (Red turtle agent rule)

```
Agt_Init{
}
Agt_Step{
    Dim redTurtleNumber as integer, blueTurtleNumber as integer,
        turtleTotal as double

    redTurtleNumber = _ViewCountAgent(my.X, my.Y, 1,
                        World.twoDimensionalSpace.redTurtle)-1
    blueTurtleNumber = _ViewCountAgent(my.X, my.Y, 1,
                        World.twoDimensionalSpace.blueTurtle)
    turtleTotal = redTurtleNumber + blueTurtleNumber

    If redTurtleNumber > 0 Then
        my.happiness = redTurtleNumber / turtleTotal
    Else
        my.happiness = 0
    End If
```

```
    if my.happiness < 0.6 then
        _MoveToSpace(my.X, my.Y, 3)
    end if
}
```

Take a close look at the Step rule. The first line defines variables used only in the Step rule. In the following block, the number of neighboring red turtles and blue turtles is counted and the total is calculated. In the third block, the neighboring-occupancy rate for red turtles is calculated, and in the fourth block, if the rate is less than 0.6, a move to an unoccupied cell is effected.

There are two new functions related to agents. The first is _ViewCountAgent(). This function returns the number of agents in neighboring cells. Its usage is _ViewCountAgent(X, Y, *range*, *agent name*). For X and Y, you ordinarily specify the coordinates of the agent itself. In specifying the range, the agent's own location is 0; to move outward in successive neighboring steps, you add 1 for each step.

For example, when you specify a range of 1 for a space in the grid model, the target for calculation is 9 cells, including the agent's own location. Incidentally, 1 is subtracted from redTurtleNumber because the agent itself is counted in the function's return value.

If you don't specify an agent name, you can a count of all neighboring agents by using All.

2	2	2	2	2
2	1	1	1	2
2	1	0	1	2
2	1	1	1	2
2	2	2	2	2

Relation between own location and step ranges (grid model)

> ***Get the number of neighboring agents — "_ViewCountAgent(X, Y, range, agent name)"***

The second function is _MoveToSpace(), which moves an agent to a neighboring unoccupied cell. Its usage is _MoveToSpace(X, Y, *movement range*). This effects movement if there is an unoccupied in the movement range centered at X, Y. If there is no unoccupied cell, it returns the value True. The preceding rule specifies movement to an unoccupied cell within three steps of the agent's own location.

> ***Move to a neighboring unoccupied cell — "_MoveToSpace(X, Y, movement range)"***

The If statement in the third block has another new element — Else. Processing to be performed in cases when the first condition doesn't apply are written between Else and EndIf. You may be wondering why the If statement branches to this Else portion. We do this because if there are no neighboring red turtles, the value of redTurtle is zero, and attempting to divide redTurtleNumber by turtleTotal would result in an error and cause the simulation to stop.

> ***"If (condition) Then (rule when condition is satisfied) Else (rule when condition is not satisfied) End If"***

Now that you've completed the rules for red turtles, try using them as the basis for writing the rules for the blue turtles. The answer is as follows.

Seg01.abs (Blue turtle agent rule)

```
Agt_Init{
}
Agt_Step{
    Dim redTurtleNumber as integer, blueTurtleNumber as integer,
        turtleTotal as double
    redTurtleNumber = _ViewCountAgent(my.X, my.Y, 1,
                        World.twoDimensionalSpace.redTurtle)
    blueTurtleNumber = _ViewCountAgent(my.X, my.Y, 1,
                        World.twoDimensionalSpace.blueTurtle)-1
    turtleTotal = redTurtleNumber + blueTurtleNumber
    If blueTurtleNumber > 0 Then
        my.happiness = blueTurtleNumber / turtleTotal
    Else
        my.happiness = 0
    End If
    if my.happiness < 0.6 Then
        _MoveToSpace(my.X, my.Y, 3)
    end if
}
```

A.2 Making It Easier to Use (Segregation model Using the Control Panel Window)

When you try running the simple segregation model covered earlier, you see that it shows exactly the same operation as the segregation model included in the tutorial. With the simple model, however, you can't change user parameters unless you start the Rule Editor. Accordingly, as the next step we'll try using the Control Panel window and the World variable to improve it to a user-friendly segregation model. Here, we'll add the following features.

- Ability to change the threshold value
- Ability to change the starting number of turtles
- Ability to quit the simulation when the turtles stop moving
- Addition of a time-series graph and the number of steps view

A.2.1 Making It Possible to Change the Threshold Value

The first thing we want to experiment with in this segregation model simulation is to see how segregation patterns change when we vary the setting (threshold value). The threshold value affects the value of neighboring-occupancy rate the turtles can stand without moving. For the first modification, let's try making it easy to set the threshold value with the Control Panel window.

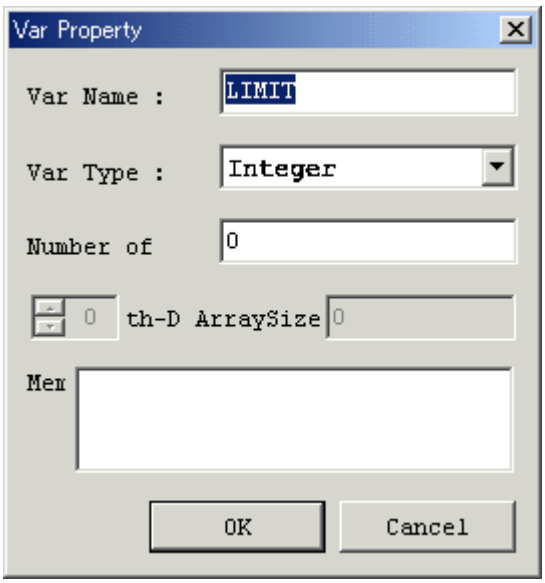
The Control Panel window is used mainly to directly manipulate the threshold values of agent rules. However, you should note that these cannot be implemented in the rules using only the Control Panel settings. We'll use the following method, which is a bit complicated.

- Create the variable to store the value you want to control directly under the World hierarchy.
- Rewrite the rules to reference the variable you created.
- Make the settings in the Control Panel window.

Creating the Variable Under the World Hierarchy

Add a single new variable directly under the World hierarchy.

Set Variable Name to Threshold, Variable Type to Double, and leave Number of Dimensions at 0.



Rewriting the Rules

Rewrite the necessary portions of the respective rules for the red turtles and blue turtles to reference the variable you just created.

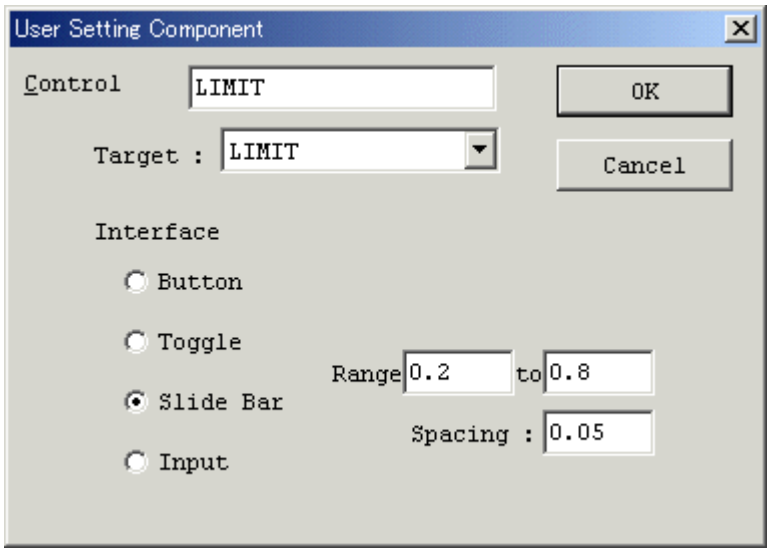
```
If my.happiness < 0.6 Then
    _MoveToSpace(my.X, my.Y, 3)
End If
```

Change the portions with this constant as follows:

```
If my.happiness < World.threshold Then
    _MoveToSpace(my.X, my.Y, 3)
End If
```

Making the Settings for the Control Panel Window

From the menu bar, select the Settings menu and choose Control Panel Settings. When the Control Panel window's User Setting List dialog box appears, click Add.



When the User Settings dialog box appears, set Control Name to Threshold and Setting Target to Threshold. For Interface, choose Slider. Set Range to 0.2 to 0.8, and Scale Interval to 0.05. When you've finished making the settings, click OK to close the window.

The User Setting List dialog box closes.

> ***Create variables to be manipulated with the Control Panel window directly under the World hierarchy.***

A.2.2 Making It Possible to Change the Starting Number of Turtles

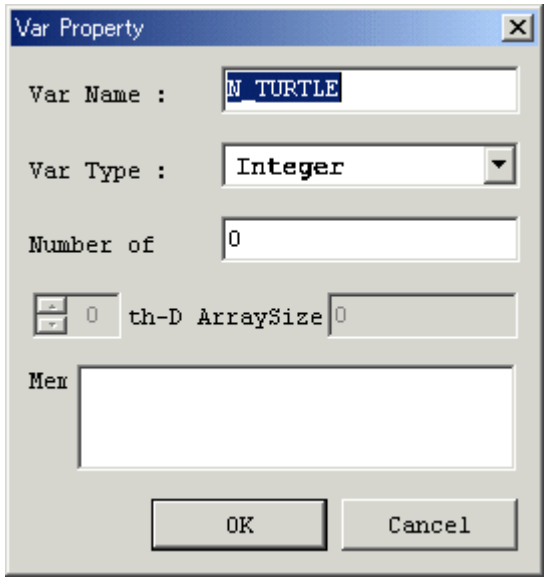
With the simple segregation model, it's necessary to set the starting number of turtles in advance with Agent Properties. However, this means that in order to investigate changes due to an increase or decrease in the number of agents, you have to go into the Tree and open Properties, which is a bit troublesome. Accordingly, for the next modification, let's try making it simple to set the starting number of turtles using the Control Panel window.

The use of the Control Panel window and the World variable are the same as we saw earlier, but in order to create just the required number of agents, you need to use a special agent function.

Creating the Variable Under the World Hierarchy

Add a single new variable immediately under the World hierarchy.

Set Variable Name to Number of Turtles, Variable Type to Integer, and leave Number of Dimensions set to 0.



Changing the Agent Properties

Because agents are created in the World initial rule, in Agent Properties, set the Number of Agents to 0 for both the red turtles and the blue turtles.

Rewriting the Rules

To create the agents, add the following statements to the World initial rule.

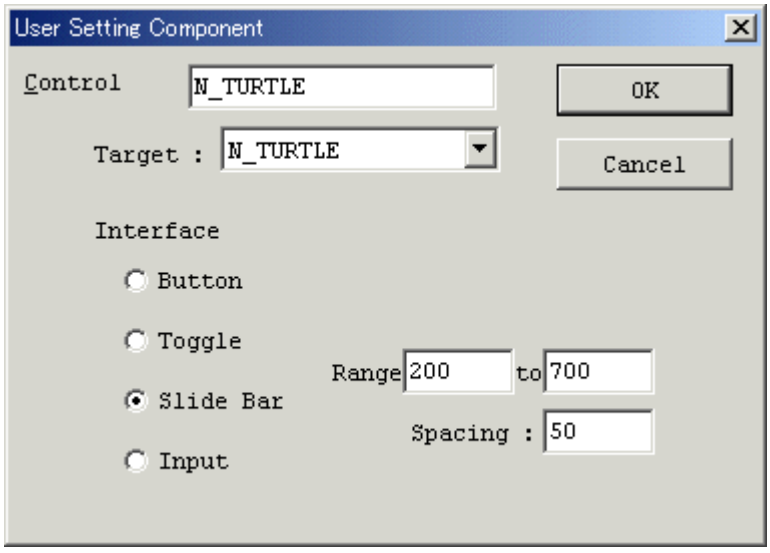
Seg02.abs (World rule)

```
Agt_Init{
    Dim i as integer
    for i = 0 to World.numberOfTurtles - 1
        _CreateAgent(World.twoDimensionalSpace.blueTurtle)
        _CreateAgent(World.twoDimensionalSpace.redTurtle)
    next i
    _RandomPutAgent(World.twoDimensionalSpace.blueTurtle, false)
    _RandomPutAgent(World.twoDimensionalSpace.redTurtle, false)
}
```

_CreateAgent() creates a single instance of the agent specified in parentheses. Combined this with the For ... Next statement, create a total of World.numberOfTurtles × 2 turtle agents.

Making the Settings for the Control Panel Window

From the menu bar, select the Settings menu and choose Control Panel Settings. When the Control Panel window's User Setting List dialog box appears, click Add.



When the User Settings dialog box appears, set Control Name to Number of Turtles and Setting Target to Number of Turtles. For Interface, choose Slider. Set Range to 200 to 700, and Scale Interval to 50.

When you've finished making the settings, click OK to close the window. The User Setting List dialog box closes.

> ***Create agents — "Use _CreateAgent(agent name)"***

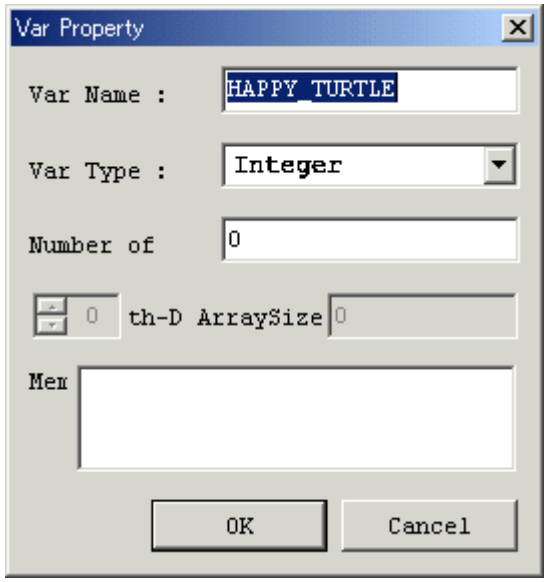
A.2.3 Quitting the Simulation When the Turtles Stop Moving

One drawback of the simple model is that the simulation continues to run on and on even when the locations of the turtles become more or less static. This means that you can't determine when (at what step) convergence occurs unless you constantly watch the simulation. For that reason, let's try revising the program so that the simulation quits automatically when the turtles stop moving. We'll use a method that involves creating a variable for the convergence condition, happyTurtles, immediately under the World hierarchy, and effecting a conditional branch according to this variable.

Creating the Variable Under the World Hierarchy

Add a single new variable immediately under the World hierarchy.

Set Variable Name to happyTurtles, Variable Type to Integer, and leave Number of Dimensions set to 0.



Rewriting the Rules

To create the agents, add the following statements to the end of the World initial rule and in the execution rules. _ExitSimulation() is a function for ending a simulation. Also, note that the equal sign used in the If *statement is ==. Agent Based Simulator uses = for assignment, but in comparison and equality statements the doubled == is always used. Be careful, because these are often confused.*

> ***End a simulation — "Use _ExitSimulation()"***

> ***In equality statements in "If" statements, use "==" (double equal sign).***

Seg03.abs (World rule)

```
Agt_Init{
    • • • (The portion up to here is the same as in the previous rule)
    _RandomPutAgent(World.twoDimensionalSpace.redTurtle, false)
    World.happyTurtles = World.numberOfTurtles * 2
}
Agt_Step{
    if World.happyTurtles == 0 then
        _ExitSimulation()
    End if
    World.happyTurtles = 0
}
```

Also add the following statements to the redTurtle and blueTurtle execution rules. These add 1 to the World.happyTurtles variable when the turtles stop moving.

Seg03.abs (Red turtle and blue turtle agent rules)

```
Agt_Step{
    • • • (The portion up to here is the same as in the previous rule)
    if my.happiness < World.threshold then
        _MoveToSpace(my.X, my.Y, 3)
    Else
        World.happyTurtles = World.happyTurtles + 1
    end if
}
```

The usage of the World.happyTurtles variable in the World agent is a bit tricky. That's because this variable is set to zero, right after the conditional statement that ends the simulation if the value of the variable is zero. It seems that a simulation should stop immediately, but in reality it works well. Why is that?

It's because rules are always execute in the sequence of first the World agent, and then the various other agents. This means that even though the variable is set to zero at each step, the movement numbers are added according to the agent rules, and are carried over to the next step. If the value of the variable remains zero in a particular step, the conditional branch at the beginning of the next step ends the simulation.

A.2.4 Adding a Time-series Graph and Step View

In the previous step we added the happyTurtles variable to World. If we could graph this numerically, we would be able to know how many turtles move in different steps. Accordingly, now let's try adding a time-series graph and display of numerical values to the output view (see Seg04.abs file).

Adding a Time-series Graph to the Output View

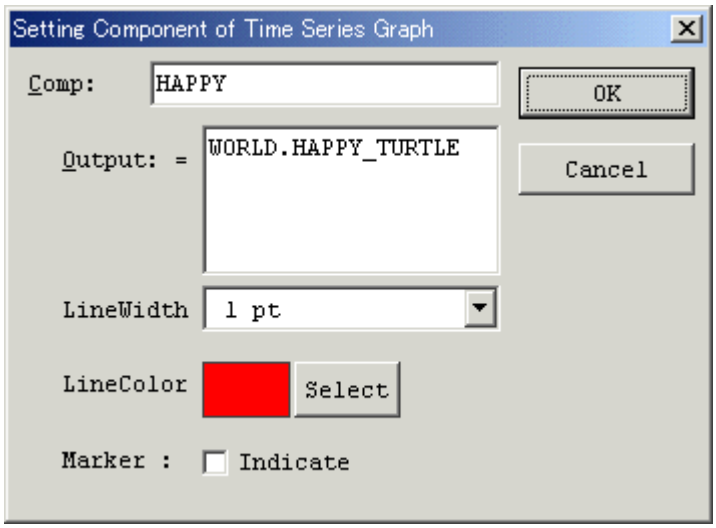
From the menu bar, select the Settings menu and choose Output.

When the Output Item List dialog box appears, select Time-series Graph as the output type to add, then click Add.

When the Time-Series Graph Settings dialog box appears, set Name and Title to Turtle Graph, and select the Show Legend check box.

Adding Graph Components (Nonmoving Turtles) to the Time-series Graph

In the Time-series Graph View dialog box, go to Graph Component List and click Add.



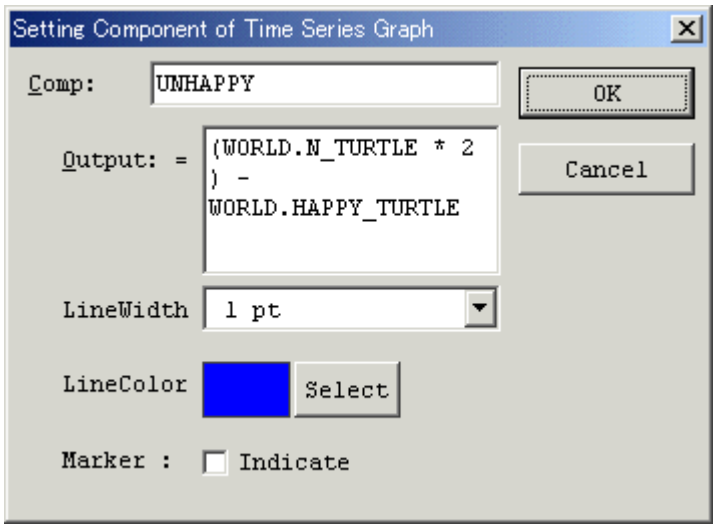
When the Time-series Graph Component Settings dialog box appears, set Component Name to Nonmoving Turtles. In the Output Value box, enter World.happyTurtles.

When you've finished making the settings, click OK to close the dialog box.

> ***In the Output Value field, specify a variable that begins with World, or enter a computational expression.***

Adding Graph Components (Moving Turtles) to the Time-series Graph

In the Time-series Graph View dialog box, go to Graph Component List and click Add.



When the Time-series Graph Component Settings dialog box appears, set Component Name to Moving Turtles. Because Nonmoving Turtles can be determined by subtracting the moving turtles from the number of agents created, in the Output Value box, enter (World.numberOfTurtles × 2) − World.happyTurtles.

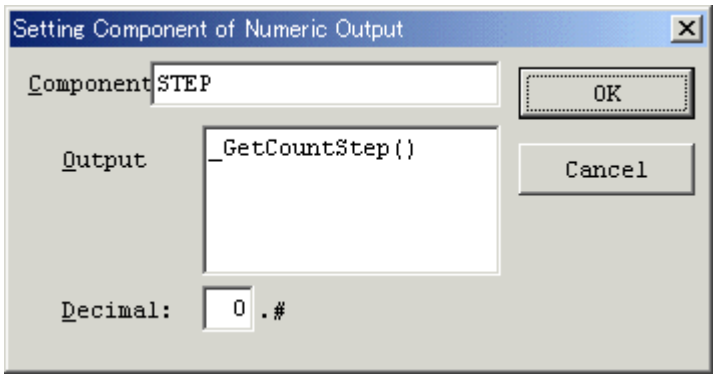
When you've finished making the settings, click OK to close the dialog box. In the Time-series Graph Component Settings dialog box, click OK to close the dialog box.

Adding Numerical Screen Output to the Output View

Select Numerical Output as the type of output to add to the Output Item List dialog box, then click Add. When the Numerical Screen Output Settings dialog box appears, set Output Name to Numerical Output, and enter Parameters as the window title.

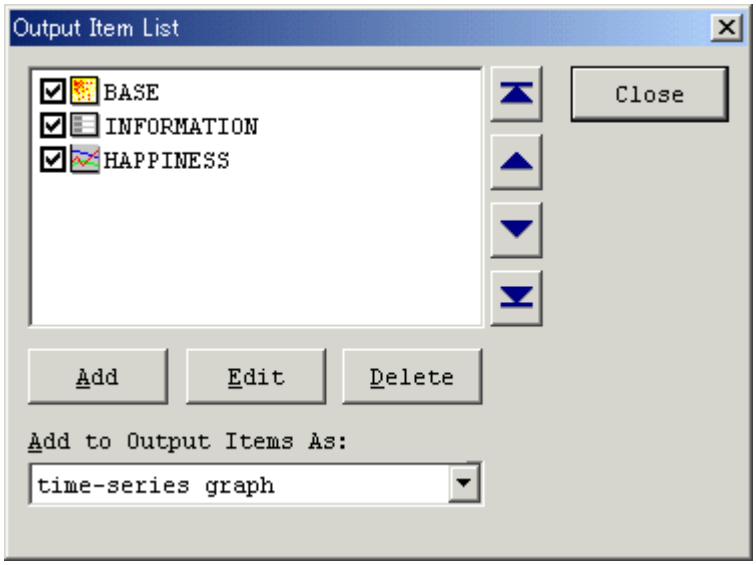
Adding the Step Number to Numerical Screen Output

In the Numerical Screen Output Settings dialog box, go to Numerical Screen Output Component List and click Add.

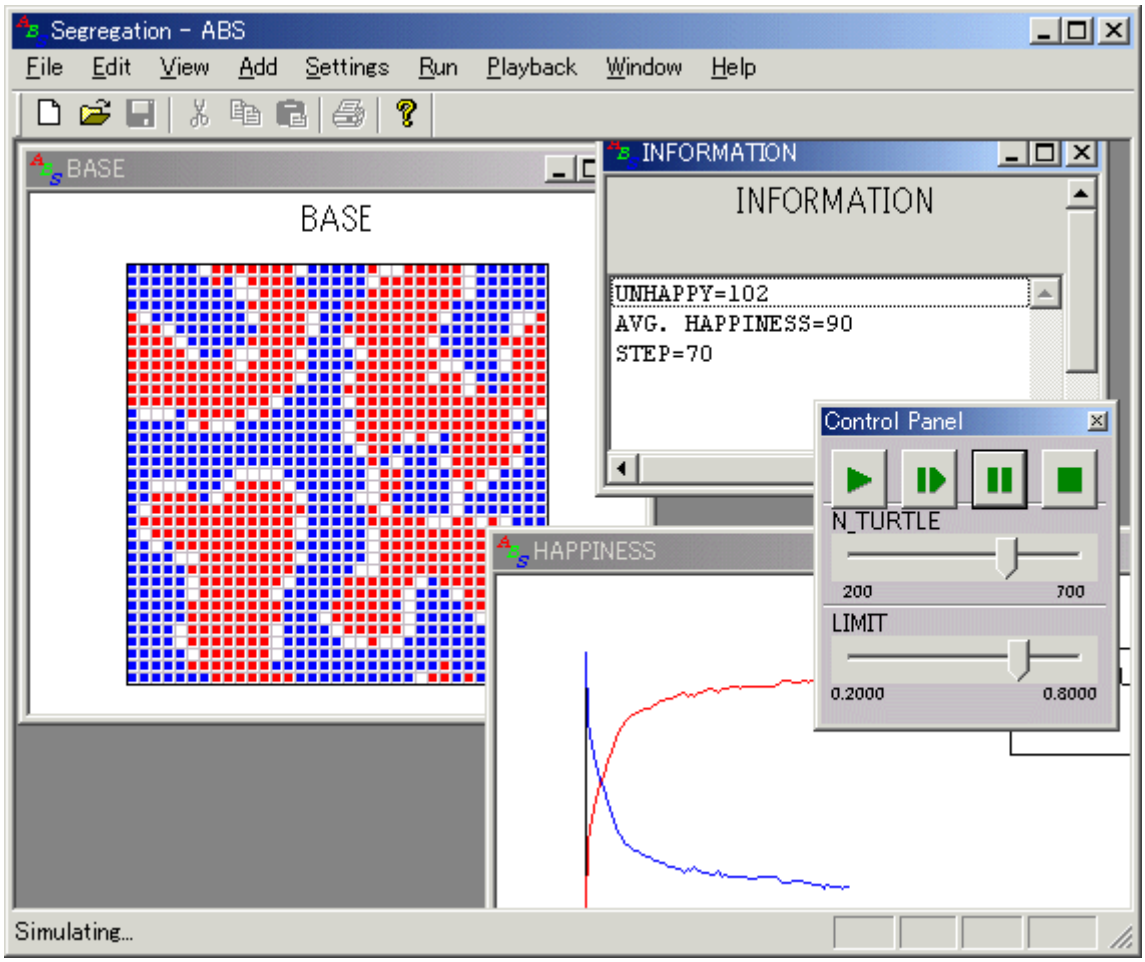


When the Numerical Screen Output Component Settings dialog box appear, for Component Name, enter Number of Steps. For Output Value, specify _GetCountStep() *to display the step number.*

When you've finished making the settings, click OK to close the dialog box. In the Numerical Screen Output Settings dialog box, click OK to close the dialog box.



Does the screen look like what you see above?
Now let's try running it. Execution result is,

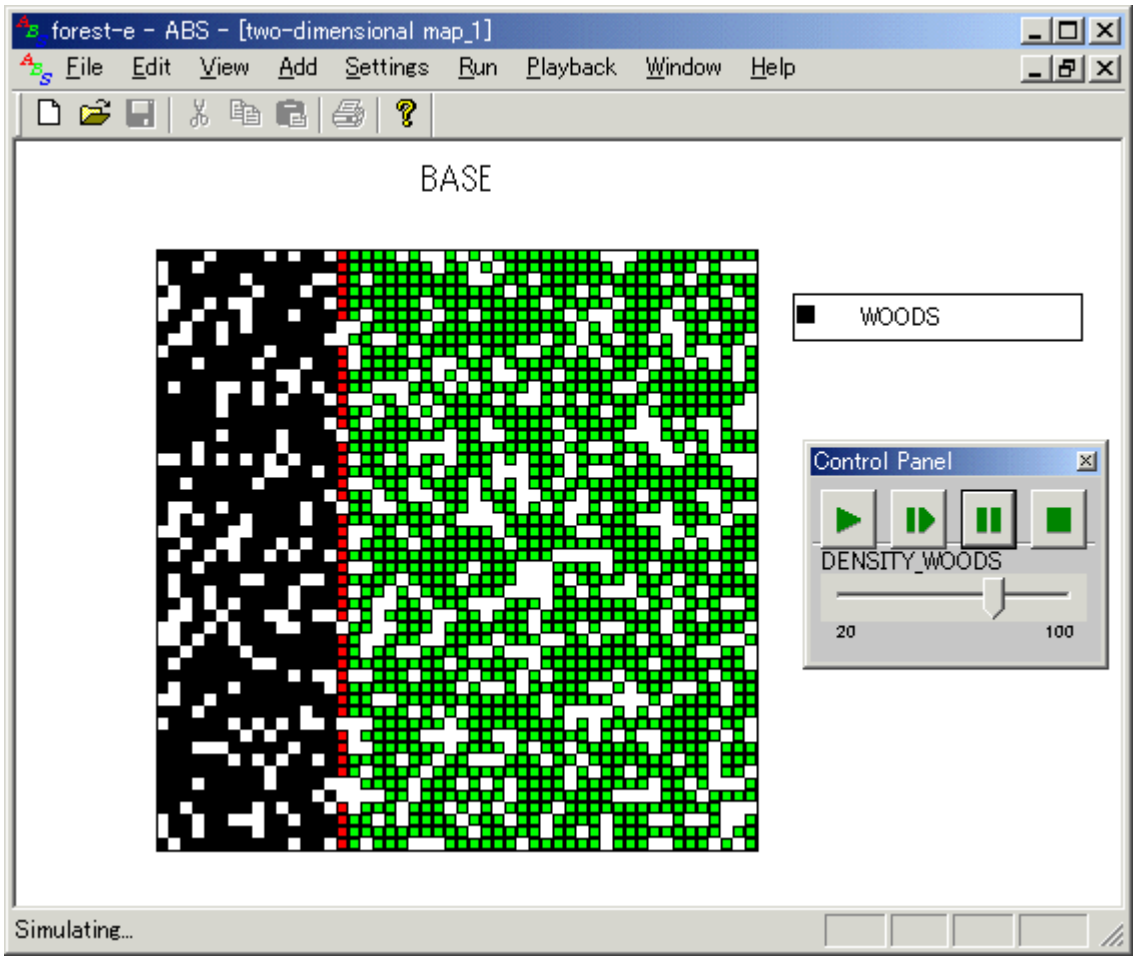

Segregation - ABS
File Edit View Add Settings Run Playback Window Help
BASE
BASE
INFORMATION
INFORMATION
UNHAPPY=102
AVG. HAPPINESS=90
STEP=70
Control Panel
N_TURTLE
200
700
LIMIT
0.2000
0.8000
HAPPINESS
Simulating...

A.3 A Fairly Complex Model Using Collections (Forest-fire Model)

We constructed the previous model using internal functions in *Agent Based Simulator*, such as _ViewCountAgent() and _MoveToSpace(). In some cases, however, internal functions may not be enough to do the job. At such times, Collection data type variables and functions can demonstrate impressive power.

Briefly put, a collection is an aggregate of objects (agents). It is used when you want to obtain a set of specific agents or conditions surrounding specific coordinates. Collections are manipulated like array variables. However, their notation is slightly idiosyncratic, so examine the example programs closely.

The example covered here is the Forest-fire model, which is based on the Forest Fire program for StarLogo. It simulates whether a fire that starts burning at the left edge of a map will spread from tree to tree to reach the right edge of the map. The probability of reaching the right edge differs greatly depending on the density of the trees.



The following describes the Forest-fire model.

1. *Tree agents are placed randomly on a map at a specified density.*
2. *Tree agents have three states; unburned (green), burning (red), and burnt (black).*
3. *A tree in the burning state becomes burnt state in the subsequent step.*
4. *If a tree is in the burning state, any unburned trees in the eight adjacent locations become burning state.*
5. *In the first step, trees on the left edge are burning.*

A.3.1 Creating a Simple Model (But Something Is a Little Strange!)

The rules for the Forest-fire model are truly simple. In the first model, we start by creating the two-dimensional space and the tree agents, then make the settings for the World variable and the Control Panel window to allow us to vary the tree density. Then we write the rules for World and the tree agents.

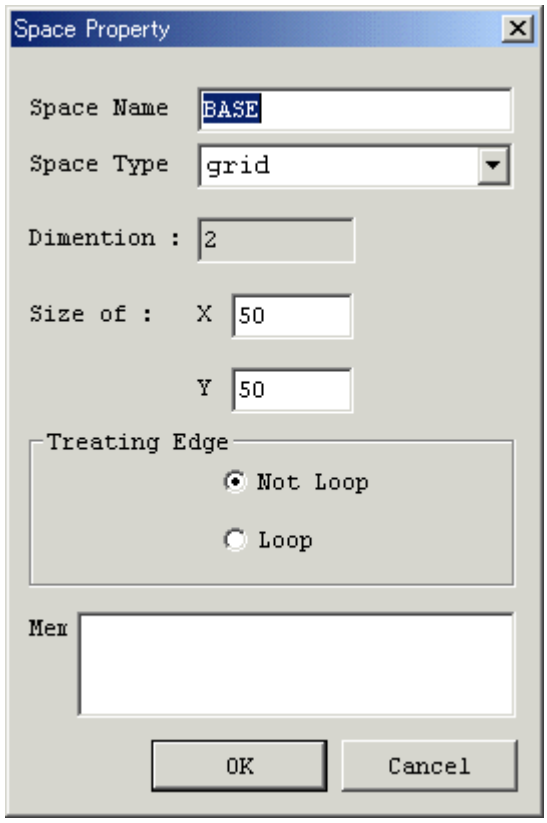
Creating a New Setting File

From the File menu, select New.

Adding the Space

Create a single new space component under the World hierarchy, then make the settings for the properties.

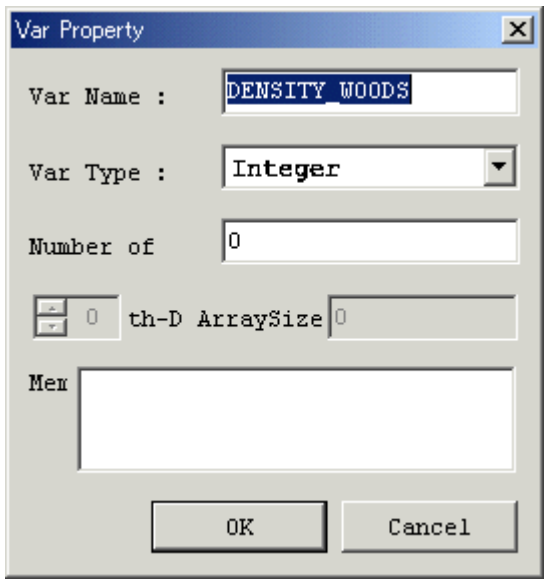
Name the space component "Two-dimensional Space". Set a size for the grid model of 50 each for both X and Y, and set it not to loop.



Adding the Variable Under the World Hierarchy

Create a single new variable under the World hierarchy.

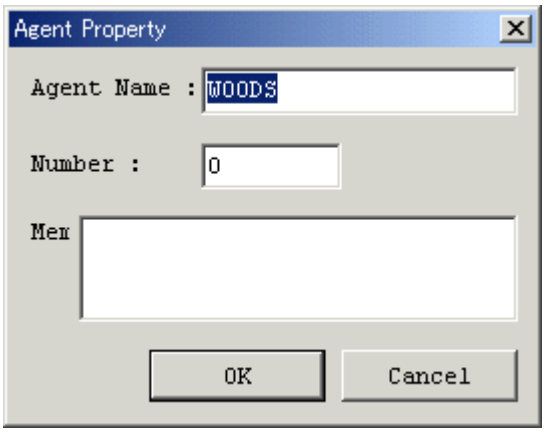
For Variable Name, enter treeDensity. Set Variable Type to Integer, and leave Number of Dimensions set at 0.



Adding the Agents

Under the Two-dimensional Space hierarchy, create a new agent and make the settings for its properties.

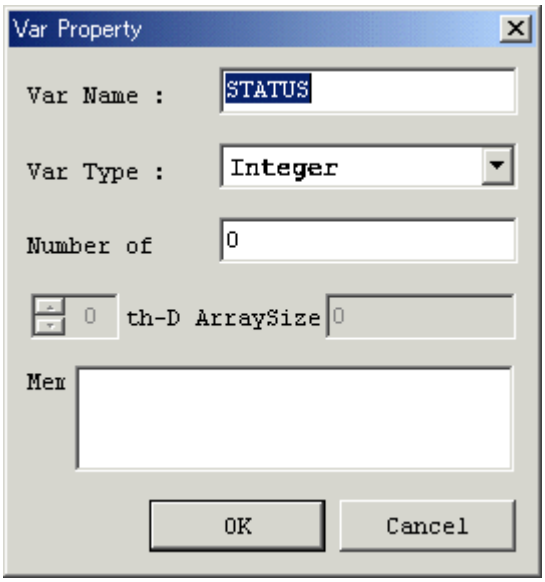
For Agent Name, enter Tree. The agents are created when the simulation runs, so set Number of Agents to 0.



Adding the Agent Variables

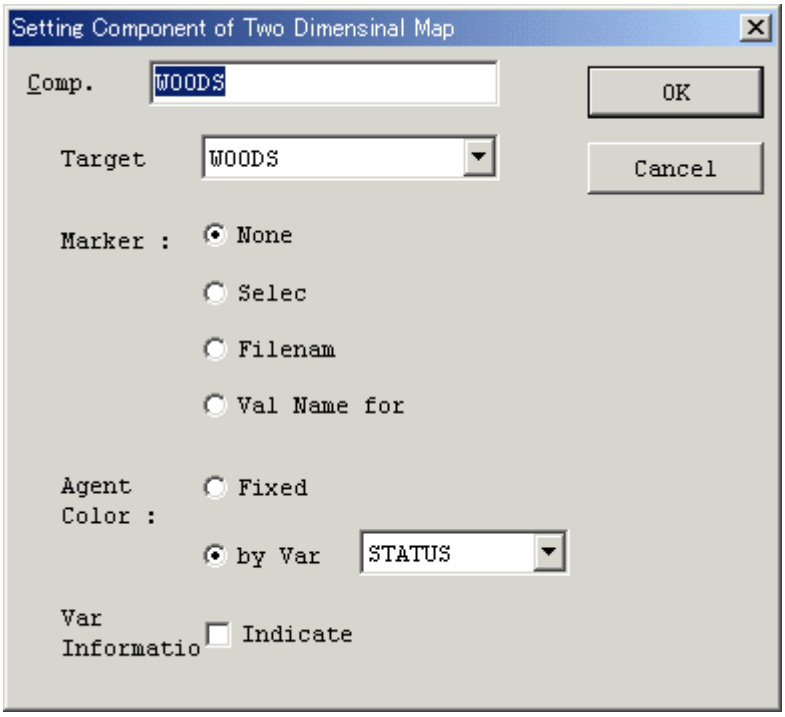
The agents need a variable to determine the state. Under the agent hierarchy, create a new variable.

For Variable Name, enter State. Set Variable Type to Integer, and leave Number of Dimensions set at 0.



Adding the Two-dimensional Map

From the Settings menu, choose Output, then add 2D Map.

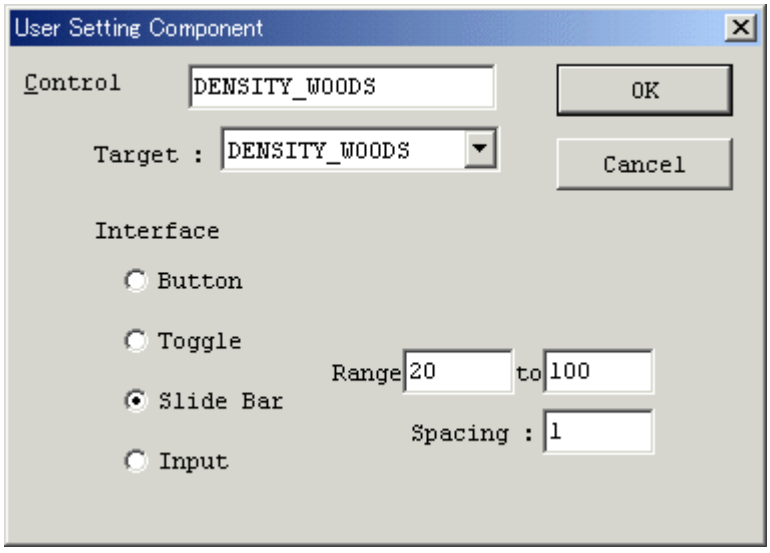


Set Map Name and Map Title to Two-dimensional Space. At the Map Component List, click Add to add the component. When the Two-dimensional Map Component Settings dialog box appears, set Component Name to Tree and set Output Target to Tree as well.Leave Marker View blank (unselected), set Agent Color to Set by Variable, and select State. Leave Agent Variable Information unselected.

When you've finished making the settings, close the Output Item List dialog box.

Making the Settings for the Control Panel Window

From the menu bar, select the Settings menu and choose Control Panel Settings. When the Control Panel window's User Setting List dialog box appears, click Add.



When the User Settings dialog box appears, set Control Name to treeDensity and Setting Target to treeDensity as well. For Interface, choose Slider. Set Range to 20 to 100, and Scale Interval to 1. When you've finished making the settings, click OK to close the window.

The User Setting List dialog box closes.

Writing the World Rule

Write the following rule for the World agent. This is not used here as the initial rule. The rule first obtains the size of the space, then calculates the number of agents according to the tree density set at the Control Panel window and randomly places the required number of agents using _CreateAgent().

Fire01.abs (World rule)

```
Agt_Init{
    Dim LimX as Integer, LimY as Integer
    Dim i as Integer, Maxi as Integer
    LimX = _GetWidthSpace(World.twoDimensionalSpace)
    LimY = _GetHeightSpace(World.twoDimensionalSpace)
    Maxi = Int(LimX * LimY * World.treeDensity * 0.01)
    For i = 1 to Maxi
        _CreateAgent(World.twoDimensionalSpace.tree)
    Next i
    _RandomPutAgent(World.twoDimensionalSpace.tree, False)
}
Agt_Step{
}
```

Writing the Tree Agent Rules

Next we write the rules for the agents. In the Initial rule, first we set the agent's own State to unburned (green). Color_Green *is a special method used to specify the displayed color on the map. Because the displayed color takes the state variable, we make such an assignment.*

In the subsequent If *statement, if the agent is at the left edge, then State becomes burning (red).*

Fire01.abs (Tree agent rule)

```
Agt_Init{
    my.state = Color_Green
    if My.X == 0 then my.state = Color_Red End If
}
Agt_Step{
    Dim neighbors as Collection
    Dim neighboringTree as Object
    Dim Stp as Integer
    If My.state == Color_Red then
        neighbors = _CollectAround(My.X, My.Y, 1 , World.twoDimensionalSpace,
                    World.twoDimensionalSpace.tree)
        For Each neighboringTree In neighbors
```

```
                If neighboringTree.state == Color_Green then
                    neighboringTree.state = Color_Red
                End If
            Next neighboringTree
            My.state = Color_Black
        End If
    }
```

The collection makes its appearance in the Step rule. The rule in this example says that if a tree's own state is burning (red), any neighboring trees in the eight adjacent locations also become burning (red). The collection is used for this neighboring portion.

The first section has Dim statements that define the variables. In addition to the collection variable, an object variable (as Object) also makes an appearance. An object variable is used to call objects from among a collection. In most cases, however, an object is an agent.

The _CollectAround() function appears in the subsequent block. This function groups agents (objects) in a range centered on specific coordinates into a collection. You may have noticed that the method used to specify it resembles that for _ViewCountAgent(), which we saw in an earlier section. However, whereas _ViewCountAgent() can only return the number of agents, a collection can perform processing that is more complex.

> ***Group the neighboring agents into a collection — "_CollectAround(X, Y, range, space name, agent name)"***

Notice the For ... Each in the next line. This is a special way of accessing each individual element of a collection. That is to say, For Each neighboringTree In neighbors indicates that the elements in the neighbors collection are to be sequentially read one by one as neighboringTree objects.

> ***Sequentially access the elements in the collection — "For Each A(Object) in B(Collection) ... Next A"***

The state variable of the neighboringTree object is read, and if the state is unburned (green), then it is changed to burning (red). As with My, it can be accessed simply by using "neighboringTree.state".

A.3.2 Synchronizing the States Using a Backup

Now the preparations are complete, let's try executing it. After you've run it a few times, you'll probably notice that the results are different from those of simulations made with StarLogo. If the spread of fire from the left edge per unit time is taken to be equal, then when 100% of the ground is covered by trees, the fire should spread to the right linearly and uniformly. But that's not what happens in this simulation.

Why not? The reason has to do with the specifications of *Agent Based Simulator*, which prevent it. *Agent Based Simulator* is a simulator for multi-agent models, but when the computer performs the processing, internal processing for each individual agent must be carried out singly and sequentially, even for multiple simultaneous events. This processing order is allocated randomly for agents other than the World agent. This means that depending on the sequence of agent processing, it's possible that a state to be read in the next step (in this rule, "burning (red)") may be read by another agent in the selfsame step, resulting in chained processing.

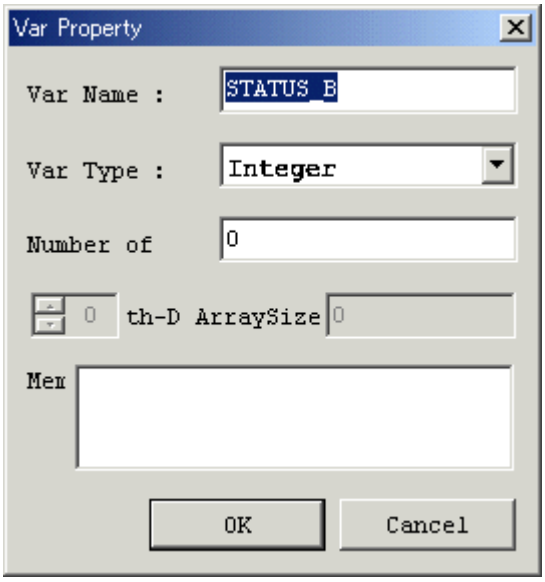
If you want to ensure that behaviors per unit time are strictly performed, you need to modify the rules. In this case, you can use the "backup" technique. A backup keeps an agent's read information (A) and write information (A) separate, and the agent temporarily holds the write information in a backup (A). After execution of all agent rules finishes, the results (A) are written en masse to the original information (A).

> ***When agent states must be synchronized in each step, use backup variables.***

The variables in this Forest-fire model that need to be backed up are the state variables for the agents, so create a backup variable called state_B.

Adding the Agent Variables

Under the agent hierarchy, create a new variable. For Variable Name, enter state_B. Set Variable Type to Integer, and leave Number of Dimensions set at 0.



Changing the World Rule

Add the rules for the backup variable to the execution rule for the World agent. The initial rule does not change.

Fire02.abs (World rule)

```
Agt_Init{
    • • • (The initial rule does not change)
}
Agt_Step{
    Dim Col as Collection, Obj as Object
    Dim i as Integer
    Col = _CollectAgent(World.twoDimensionalSpace.tree)
    For Each Obj in Col
        Obj.state = Obj.state_B
    Next Obj
}
```

This execution rule writes the back up variable to the original variable.
First, all tree agents are stored in the Col variable, then the state_B backup variable for each agent (object) is assigned to state variable.

Changing the Tree Agent Rules

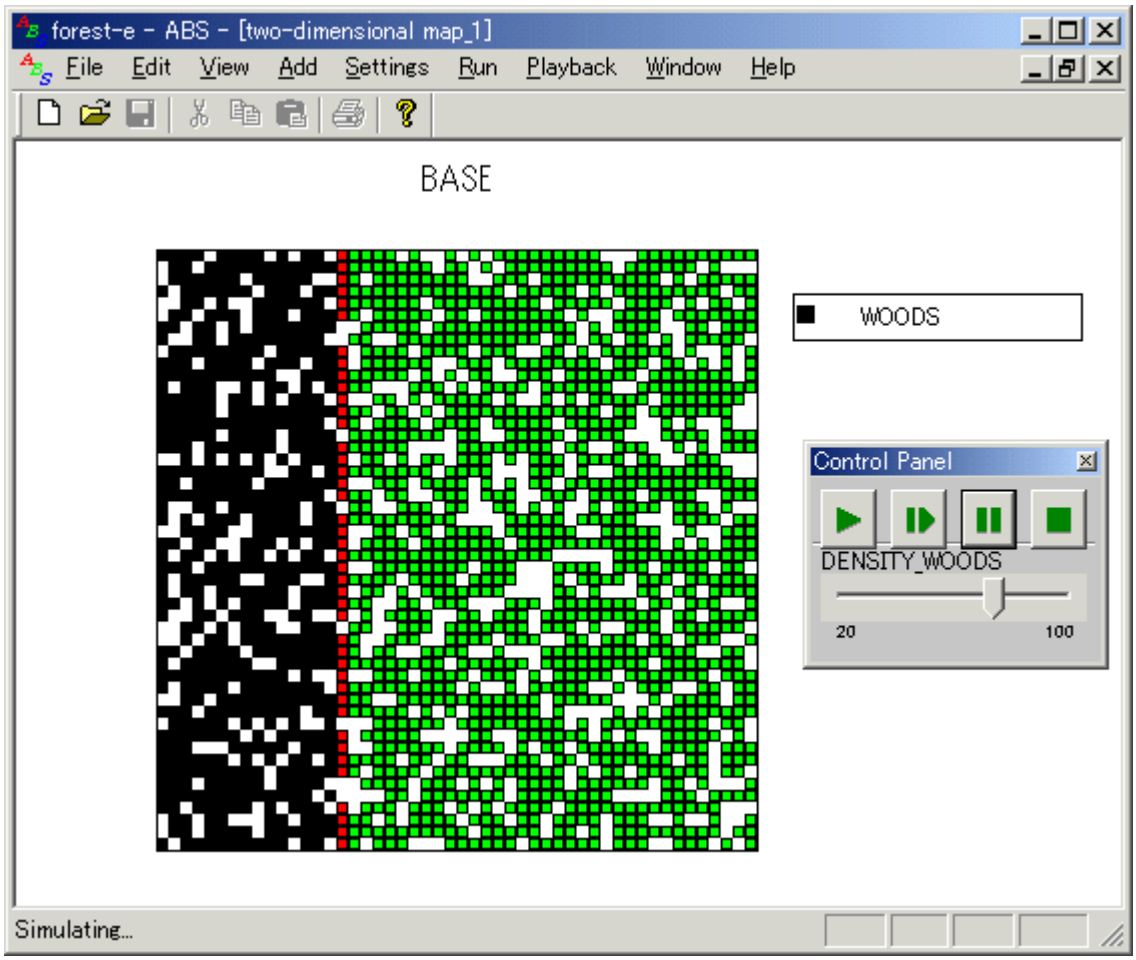
Add the rules for backup variables to the tree agent rules. What you need to do is to change the portions that write to the state variable to write to the state_B variable.

Fire02.abs (Tree agent rule)

```
Agt_Init{
    my.state = Color_Green
    my.state_B = Color_Green
    if My.X == 0 then
        my.state_B = Color_Red
    End If
}
Agt_Step{
    Dim neighbors as Collection
    Dim neighboringTree as Object
    Dim Stp as Integer
    If My.state == Color_Red then
        neighbors = _CollectAround(My.X, My.Y, 1 , World.twoDimensionalSpace,
                                   World.twoDimensionalSpace.tree)
        For Each neighboringTree In neighbors
            If neighboringTree.state == Color_Green then
                neighboringTree.state_B = Color_Red
            End If
        Next neighboringTree
        My.state_B = Color_Black
    End If
}
```

How does the simulation work now?

The backup should function correctly, and you should no longer see operation where fire suddenly spreads to several sites in one step.



A.3.3 Adding Display of Required Numerical Values to Simulation Execution

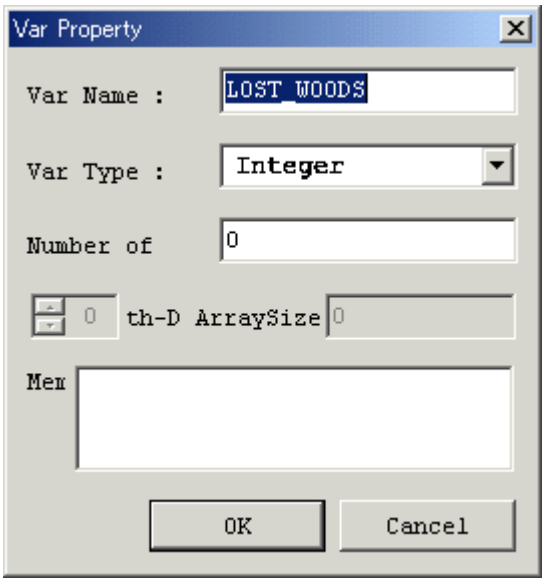
Now that we've eliminated some quirks in behavior, let's try adding a screen to show the parameters that are required during execution. The ones we need here are Step Number, Burned Tree Agents, and Burnt Rate. You can get the step number using _GetCountStep(). For Burned Tree Agents, create the variable immediately under World and increment it when an agent changes to the burnt state.

Adding the Variable Under the World Hierarchy

Create a new variable under the World hierarchy. For Variable Name, enter burntTree. Set Variable Type to Integer, and leave Number of Dimensions set at 0.

Rewriting the Tree Agent Rules

Now rewrite part of the tree agent rules. Change them to add 1 to the World.burntTree variable when a tree is burnt.



Fire03.abs (Tree agent rule)

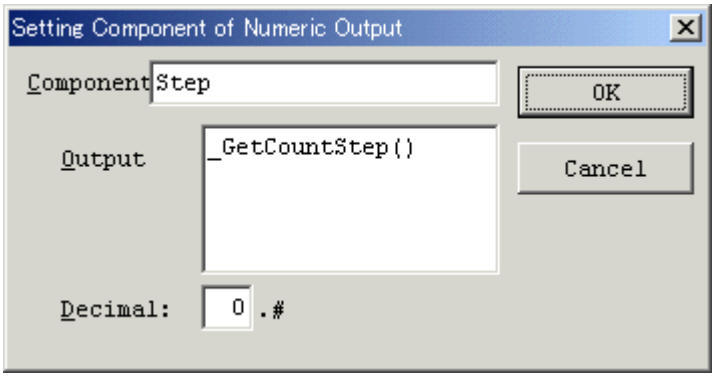
```
Agt_Step{
    • • • (The initial rules and execution rules up to here are the same as in Fire02.abs)
        For Each neighboringTree In neighbors
            If neighboringTree.state == Color_Green then
                neighboringTree.state_B = Color_Red
            End If
        Next neighboringTree
        My.state_B = Color_Black
        World.burntTree = World.burntTree + 1          • • • Add this line.
    End If
}
```

Adding Numerical Screen Output to the Output View

From the menu bar, select the Settings menu and choose Output. When the Output Item List dialog box appears, select Numerical Output as the output type to add, then click Add.

When the Numerical Screen Output Settings dialog box appears, leave Output Name set to Numerical Output_1, and enter Parameters as the window title.

Adding the Step Number to Numerical Screen Output

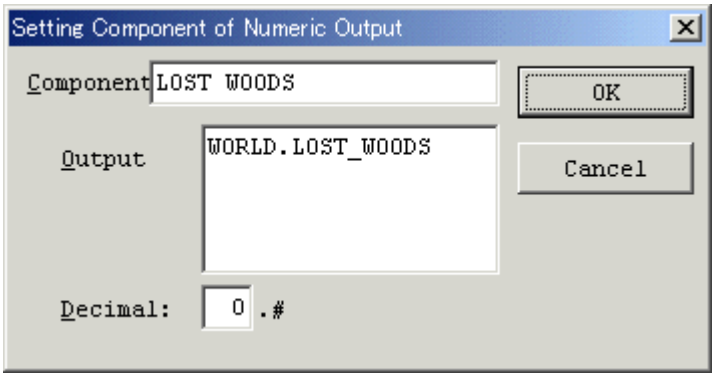


In the Numerical Screen Output Settings dialog box, go to Numerical Screen Output Component List and click Add.

When the Numerical Screen Output Component Settings dialog box appear, for Component Name, enter Number of Steps. For Output Value, specify _GetCountStep() *to display the step number.*

When you've finished making the settings, click OK to close the dialog box.

Adding Burnt Trees to the Numerical Screen Output

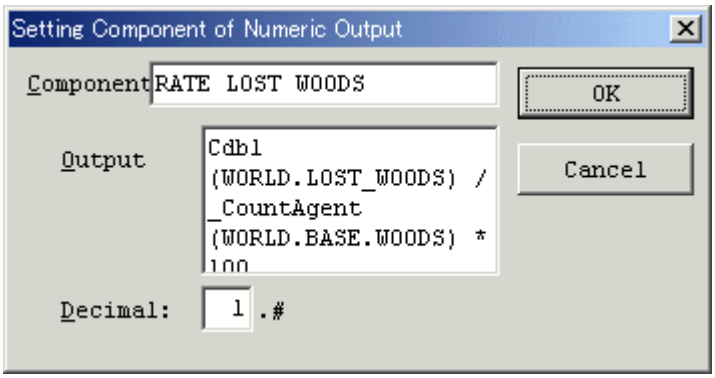


In the Numerical Screen Output Settings dialog box, go to Numerical Screen Output Component List and click Add.

When the Numerical Screen Output Component Settings dialog box appear, for Component Name, enter Burnt Trees. For Output Value, enter World.burntTree.

When you've finished making the settings, click OK to close the dialog box.

Adding Burnt Rate to the Numerical Screen Output



In the Numerical Screen Output Settings dialog box, go to Numerical Screen Output Component List and click Add.

*When the Numerical Screen Output Component Settings dialog box appear, for Component Name, enter Burnt Rate. For Output Value, specify "Cdbl(World.burntTree) / _CountAgent(World.twoDimensionalSpace.tree) * 100". Set Show Fractional Numbers to one digit.*

When you've finished making the settings, click OK to close the dialog box.
In the Numerical Screen Output Settings dialog box, click OK to close the dialog box.

The function Cdbl() appears in Output Value for the burnt rate. This converts the data type of the value within the parentheses to Double data type. Why do we go to the trouble of converting

to floating-point numbers when World.burntTree can hold only integers? The reason is because the results of division are affected. If you try eliminating Cdbl(), the calculation results are always zero. Because of the way internal processing performed in *Agent Based Simulator*, the result of an "Integer data type – operator – Integer data type" operation is always Integer data type, so the portion to the right of the decimal point in the result of the division operation is truncated. In order make the result a real number, we must make one or the other of the numerical values the Double data type.

Type-conversion Functions

To use a variable in *Agent Based Simulator*, you must declare the type of the data the variable handles. These types include Integer data type, Double data type, and String data type, but there are times when you want a value of a different type from the original one. The foregoing case, where you want to get a floating-point number by dividing two integers is a typical example. At such times, you use type-conversion functions. Cdbl() converts to Double data type, Cint() to Integer data type, Cstr() to String data type, and Cbool() to Boolean data type (True or False).

A.3.4 Changing the Pattern of How the Forest Fire Spreads

In the Forest fire model, the fire starts spreading all at once from the left edge. Now let's add different kinds of variations to this.

(1) Rules for Starting the Spread of Fire from One Location at the Center of the Map

A wildfire usually starts at one location, so this makes the fire start to spread from the center of the map. You need to change the initial rules for World and the tree agents.

Fire04.abs (World rule)

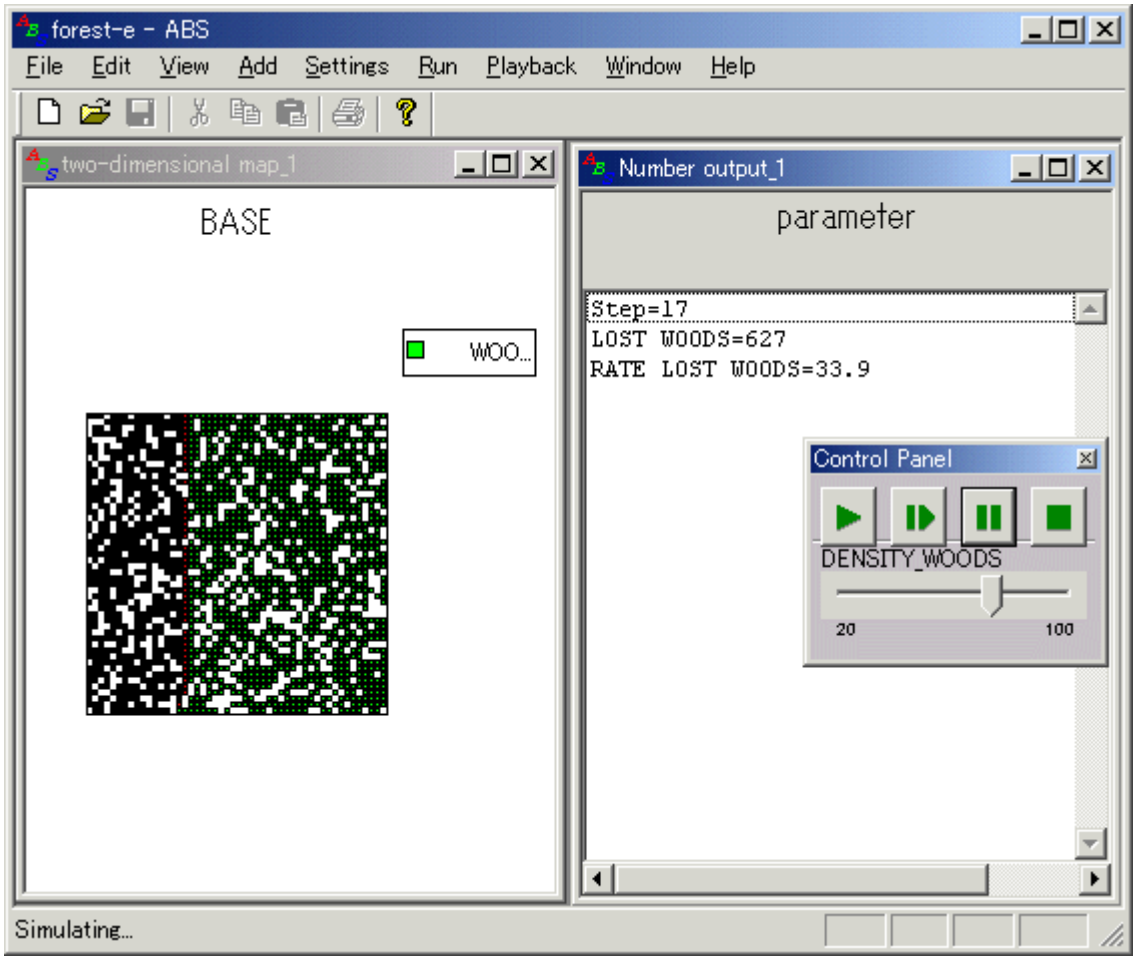
```
Agt_Init{
    Dim LimX as Integer, LimY as Integer
    Dim i as Integer, Maxi as Integer
    Dim Col as Collection, Obj as Object
    LimX = _GetWidthSpace(World.twoDimensionalSpace)
    LimY = _GetHeightSpace(World.twoDimensionalSpace)
    Maxi = Int(LimX * LimY * World.treeDensity * 0.01)
    For i = 1 to Maxi
        _CreateAgent(World.twoDimensionalSpace.tree)
    Next i
    _RandomPutAgent(World.twoDimensionalSpace.tree, False)
    Col = _CollectAround(int(LimX/2), int(LimY/2), 0,
            World.twoDimensionalSpace, All)
    if _CountCollection(Col) > 0 then
        Obj = _GetObject(Col,0)
        Obj.state_B = Color_Red
    else
        World.twoDimensionalSpace.tree.X(0) = int(LimX/2)
        World.twoDimensionalSpace.tree.Y(0) = int(LimY/2)
        World.twoDimensionalSpace.tree.state_B(0) = Color_Red
    end if
}
```

Fire04.abs (Tree agent rule)

```
Agt_Init{
        if my.state_B <> Color_Red then
                my.state = Color_Green
                my.state_B = Color_Green
        end if
}
```

In the World initial rule, the first section is almost the same as before, but the second half is very different. In broad terms, the rule means this; If there is a tree at the center of the map, it is burning. If there is no tree, then move the first tree agent (having an ID of 0) to the center of the map, and make it burning.

For the tree agents, the trees other than the one that is burning must be initialized to unburned (green), so we change the conditional statement to take trees that haven't prior been assigned Color_Red and make them unburned (Color_Green).



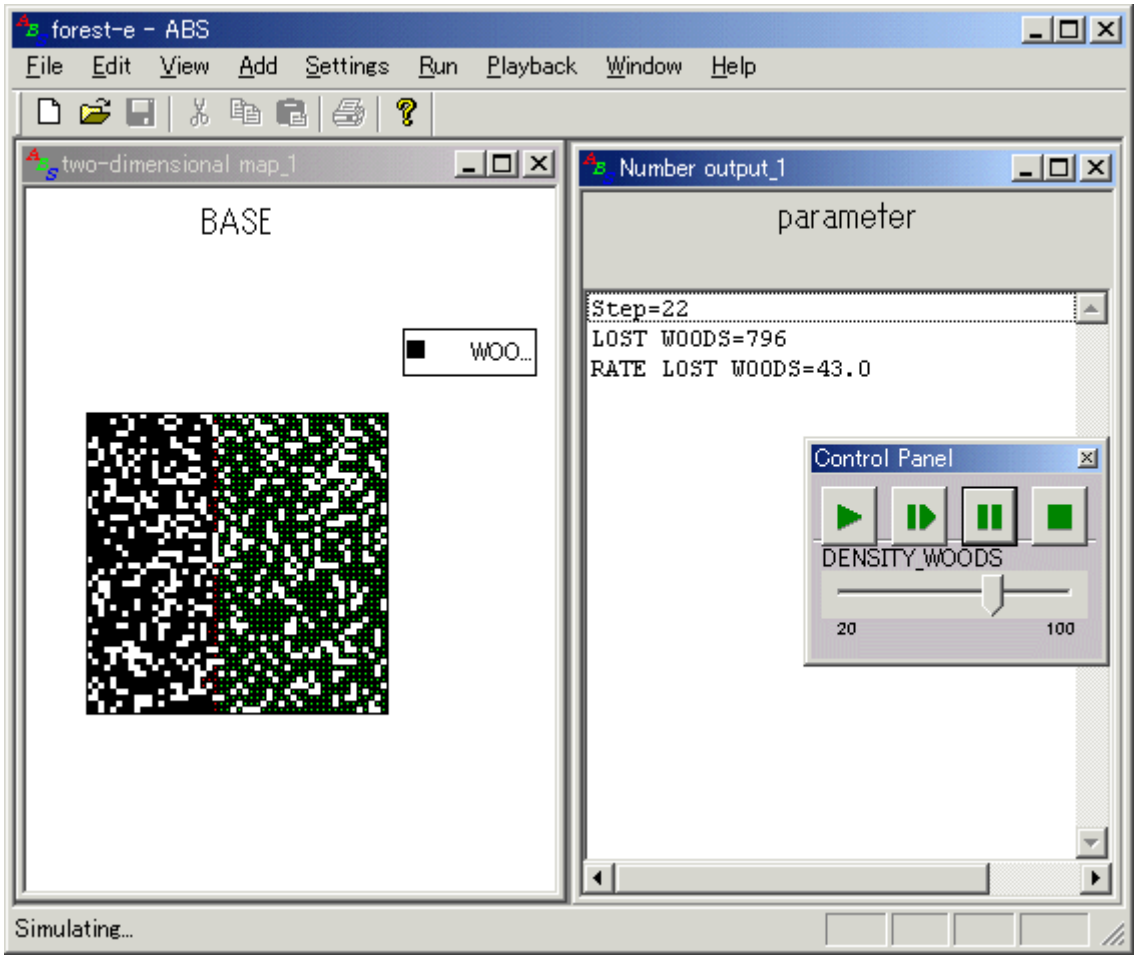
(2) Changing the number of Neighborhoods

In cases where wind direction exerts an effect, fire does not readily spread in the upwind direction. Here, we make the settings so the wind blows from the left edge, the fire spreads only downwind — that is, to the front and the side (5 directions) — and the fire does not spread to the rear (3 directions).

Fire05.abs (Tree agent rule)

```
Agt_Step{
    Dim neighbors as Collection
    Dim neighboringTree as Object
    Dim Stp as Integer
        If My.state == Color_Red then
        neighbors = _CollectAround(My.X, My.Y, 1 , World.twoDimensionalSpace,
                                   World.twoDimensionalSpace.tree)
        For Each neighboringTree In neighbors
            If neighboringTree.state == Color_Green
              AND neighboringTree.X <> My.X - 1 then
                neighboringTree.state_B = Color_Red
            End If
        Next neighboringTree
        My.state_B = Color_Black
        World.burntTree = World.burntTree + 1
    End If
}
```

This is fairly simple. You are just required the conditional statement that detect the five neighboring tree agents. In this case, the condition is satisfied only when the state is green and the X coordinate is not the agent's own coordinate minus one (that is, not upwind).



You can also rewrite the rule to change the number of neghborhoods from eight to four. In this case, add the conditional statement that detects agents with the same X or Y coordinate as the agent.

```
If neighboringTree.state == Color_Green AND ((neighboringTree.X == My.X) OR (neighboringTree.Y == My.Y)) then
```

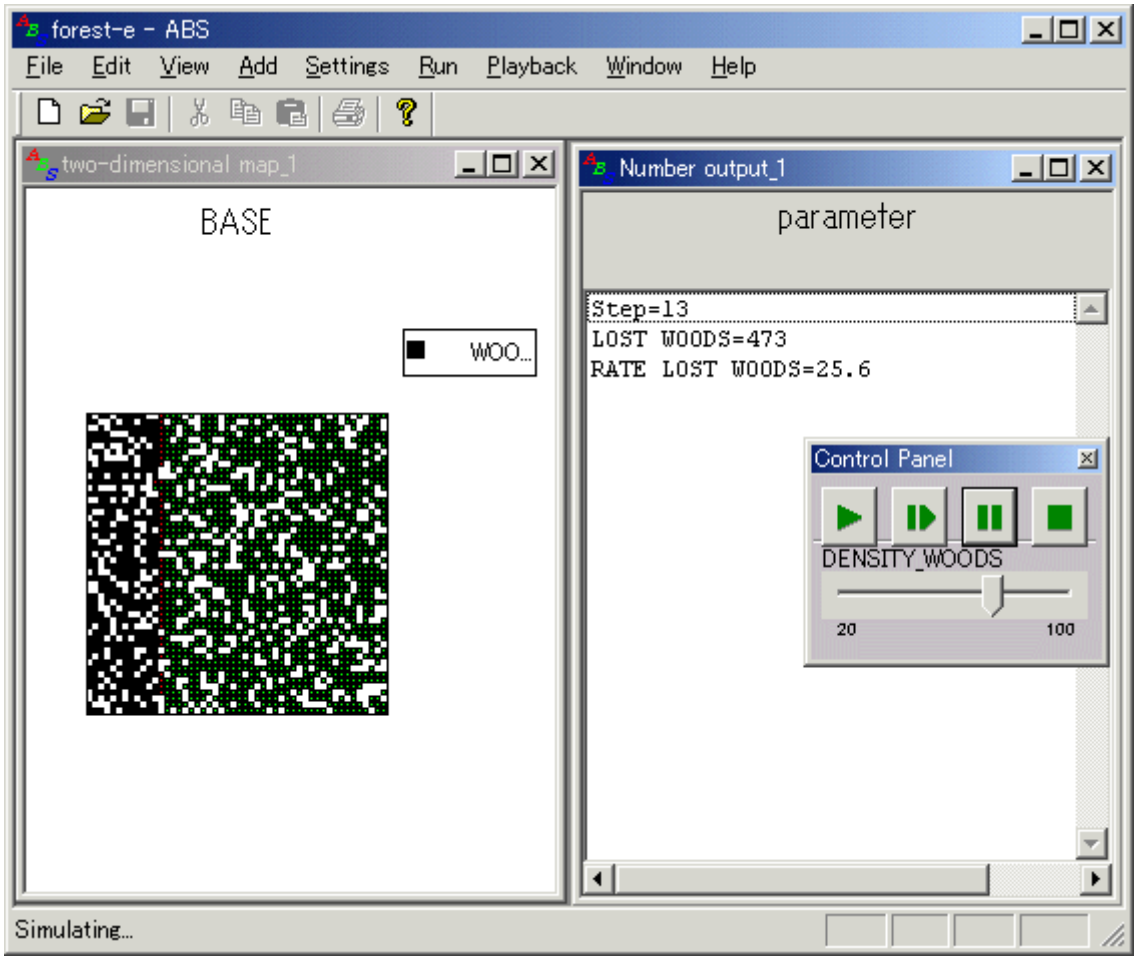
(3) Rules for Jumping Sparks

You can also make fire spread between trees that are not directly touching. Jumping sparks usually occur only when the wind is strong, so let's add this to the rule we created in (2).

Fire06.abs (Tree agent rule)

```
Agt_Step{
    Dim neighbors as Collection
    Dim neighboringTree as Object
    Dim Stp as Integer
    If My.state == Color_Red then
        neighbors = _CollectAround(My.X, My.Y, 1 ,
                World.twoDimensionalSpace, World.twoDimensionalSpace.tree)
        For Each neighboringTree In neighbors
            If neighboringTree.state == Color_Green
              AND neighboringTree.X <> My.X - 1 then
                neighboringTree.state_B = Color_Red
            End If
        Next neighboringTree
        neighbors = _CollectAround(My.X, My.Y, 4 ,
                World.twoDimensionalSpace, World.twoDimensionalSpace.tree)
        For Each neighboringTree In neighbors
            If neighboringTree.state == Color_Green
              AND neighboringTree.X > My.X + 1 then
                If Int(Rnd()*100) == 0 then
                    neighboringTree.state_B = Color_Red
                End if
            End If
        Next neighboringTree
        My.state_B = Color_Black
        World.burntTree = World.burntTree + 1
    End If
}
```

This rule uses the neighbors collection twice. In the second use, neighbors are collected with a scope of 4, and sparks jump from a burning tree to a distant agent with a probability of 1 in 100.


forest-e - ABS
File Edit View Add Settings Run Playback Window Help
two-dimensional map_1
BASE
WOO...
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parameter
Step=13
LOST WOODS=473
RATE LOST WOODS=25.6
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DENSITY_WOODS
20
100
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